MAKING DELHI HEAT-RESILIENT

A roadmap with the focus on vulnerable groups

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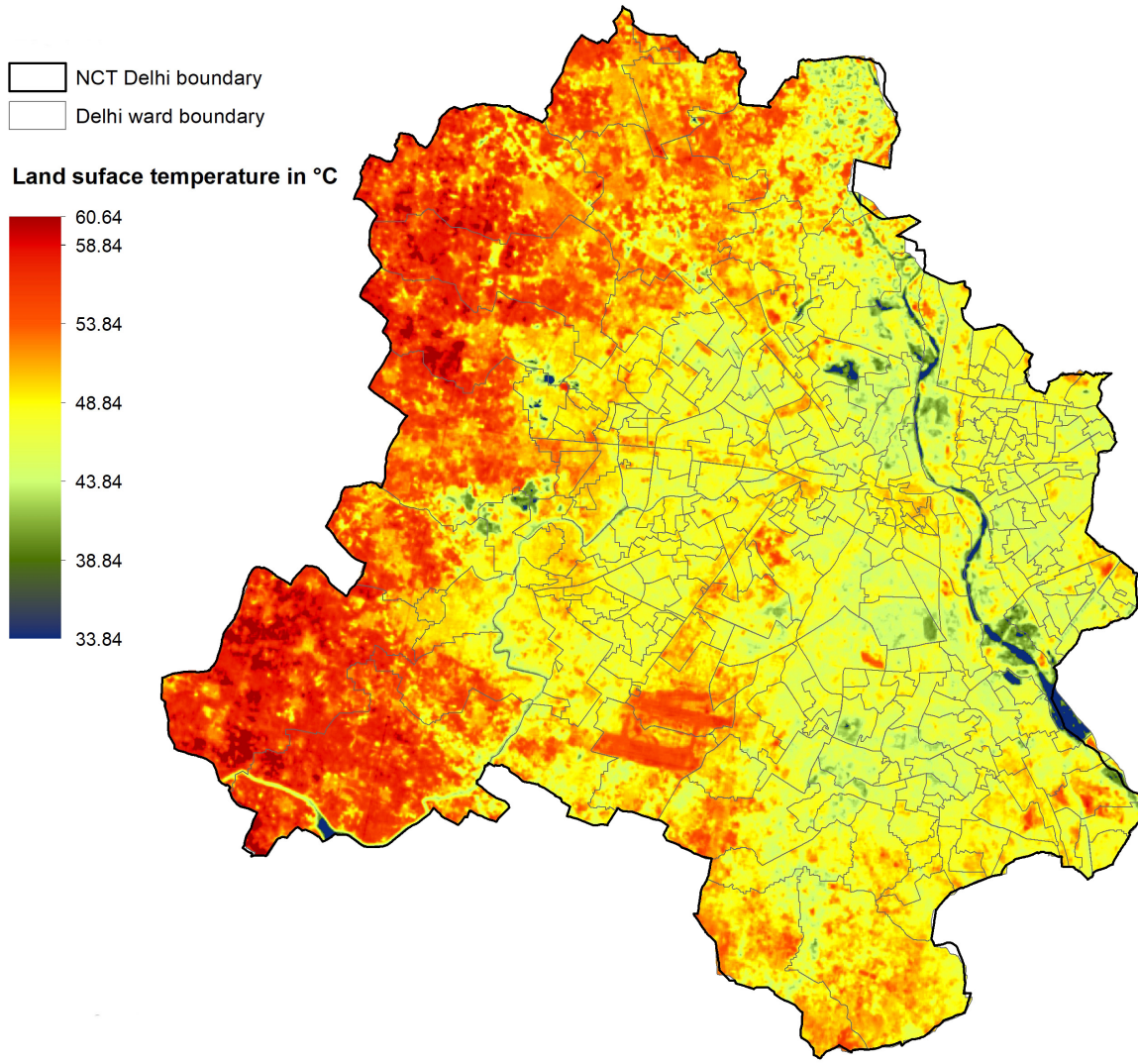
Map 1: A heat map of Delhi

A typical May month pushes land surface temperatures (LST) in Delhi as high as 60°C in some places. Mean LST across Delhi lies around 48.46°C with around two-third wards witnessing LST above 45°C on May 27, 2024. While April and May engulf the city in dry heat, June, July and August add humidity to the already high temperatures making days and nights unbearably hot. City's periphery undergoing urban transition bears the biggest brunt of this with more heat trapping surfaces and heat emitting activities. Unfortunately, these areas also house more population compared to the rest of the city, increasing exposure of the vulnerable communities like street vendors, construction workers, informal settlement dwellers, women, children among others.



Source: Created by CSE based on USGS Earth Explorer (Landsat 8/9) and Census 2011 data

1 EXECUTIVE SUMMARY

Delhi is in the grip of an escalating urban heat crisis: dangerously high 'feels-like' temperatures are causing fatalities, and are projected to result in severe economic losses equivalent to up to 4.5 per cent of India's gross domestic product (GDP). Geospatial analysis confirms that 75.78 per cent of Delhi's area is persistently heat-stressed, a condition worsened by the dramatic shrinking of the city's green cover. Current actions to contain this crisis are proving to be insufficient because of a lack of a targeted resilience strategy for highly vulnerable groups such as construction workers, street vendors and informal settlement dwellers, many of whom reside or work in heat hotspots.

To mitigate this pervasive threat, this study proposes a dual-strategy roadmap:

- Implementing year-round, city-wide actions such as mandating thermally efficient roofs and utilising better heat indicators.
- Focused interventions for exposed populations, including enforcing mandatory cooling breaks, staggering work timings, and providing dedicated fiscal support during extreme heat emergencies.

The growing heat crisis and its impacts

Delhi faces a deepening crisis from rising temperatures, with 'feels-like' temperatures reaching as high as 52°C in 2025, according to the India Meteorological Department. In 2024, the Union Ministry of Health and Family Welfare had reported 25 heat-related deaths in the city – while independent reports put this number at more than 55.

The crisis poses significant economic and health risks. Heat exposure affects productivity, and can potentially cause a loss equivalent to 4.5 per cent of India's GDP – approximately US $150-250 billion – by the end of this decade. Delhi, which contributes 3.7 per cent of India's GDP, will naturally be deeply impacted.

Extreme heat conditions trigger an uptick in the reliance on air conditioners: with AC ownership tripling in the past decade, this has exacerbated the urban heat island effect and the city's cooling inequity by ejecting waste heat into the ambient environment. This cycle also strains the energy curve, pushing Delhi's peak electricity demand to record highs – the demand has been projected to reach 9,000 MW by the end of 2025.

Heat vulnerability assessment and its key findings

Delhi's existing heat action plan, while initiating action, misses out on a resilience strategy for vulnerable groups. These groups, estimated to be as high as 50 per cent of the city's residents, include children, elderly, women, outdoor workers (construction workers and street vendors), homeless individuals, and residents of informal settlements.

Centre for Science and Environment (CSE) conducted a geospatial analysis (using Landsat data from 2015 to 2024) to identify areas persistently crossing a Land Surface Temperature (LST) threshold of 45°C.

Key spatial and environmental findings

- **Widespread heat stress:** 75.78 per cent of Delhi's area is persistently heat-stressed (LST > 45°C for six or more years). Nearly 98.72 per cent of the city's total area crossed the heat threshold at least once over the decade.
- **Heat hotspots:** Heat spots include industrial areas (Bawana, Mayapuri and Mundka), high-density low-rise residential colonies, and even newly built complexes (like Bharat Mandapam and East Kidwai Nagar).
- **Loss of natural sinks:** The city's natural defenses are diminishing; green cover has shrunk from 25.36 per cent in 2014 to 14.14 per cent in 2024. Waterbody footprints have reduced from 1.25 per cent to 0.99 per cent in the same period.
- **Mitigation opportunity:** Cool areas like Lutyen's Delhi, Civil Lines and Delhi Cantonment have remained below the stress threshold, largely due to extensive shading over paved surfaces provided by trees. This points to the crucial role of dense canopy cover. At the same time, 35 per cent of existing green/blue areas are themselves heat-stressed, underscoring that the quality – and not just the quantity – of greens matters.

Vulnerability overlays

The CSE assessment overlaid heat-stressed areas with the locations of vulnerable groups:

- **Construction workers:** 77 per cent of active construction sites reviewed are located in areas experiencing recurring extreme heat. The temporary dwellings (often made of heat-retaining materials like tin sheets) of workers who toil on these sites offer poor thermal comfort and adaptive capacity.
- **Street vendors:** 84 per cent of mapped marketplaces are situated in areas with recurrent heat stress. Street vendors who operate in the open at these marketplaces face prolonged outdoor exposure and livelihood loss on hot days. Microclimate simulations demonstrated that combining canopy trees and lightweight artificial canopies can bring LST down by as much as 20°C.
- **Informal settlement dwellers (JJ *basti*s):** 76 per cent of mapped JJ *basti*s, housing nearly 1.32 million people, are located in heat-stressed areas. These dwellings are typically overcrowded and built with heat-retaining materials.
- **Physiological vulnerability (women, children and elderly):** Wards with the highest concentration of these sensitive groups (such as Matiala, Hastsal and Kunwar Singh Nagar) often fall within recurring heat-stressed areas. Notably, 80 per cent of the 1,066 schools mapped in the city are in heat-stressed areas.
- **Cumulative hotspots:** 35 wards, primarily located at the city›s periphery (Matiala, Kakraula and Narela) and dense core (Chandni Chowk), exhibit 'Very High' to 'High' cumulative vulnerability, demanding urgent and prioritised action.

A roadmap for resilience

Year-round strategies (city-wide)

- **Policy and governance:** Delhi must formally recognise heat as a disaster to utilise the State Disaster Response Fund for relief and mitigation.
- **Alert systems:** Adopt better indicators for heat alerts, such as the Heat Index or wet bulb temperature, which account for humidity and 'felt' heat, instead of relying solely on maximum air temperature.
- **Information management:** Develop a dynamic heat stress dashboard for public dissemination of real-time heat alerts, warnings and advisories tailored to specific wards and vulnerable groups.
- **Built environment interventions:** Mandate and prioritise thermally-efficient roofs (cool roofs) in industrial areas, office complexes, markets and informal settlements, as they can reduce indoor temperatures by up to 5°C. Implement climate-appropriate planning and passive design principles in new buildings and in those that need retrofitting.

Groups vulnerable to extreme heat stress in Delhi constitute almost 50 per cent of the city's residents. Delhi's heat action plan needs to incorporate a resilience strategy for these groups

VIKAS CHOUDHARY / CSE

- **Infrastructure:** Proactively develop and repurpose existing public buildings (schools and community centres) as 'public cooling centres' and emergency shelters, complete with safe water and sanitation (when not in primary use).
- **Financing:** Leverage existing government schemes (PMAY, AMRUT) and access international funding mechanisms like the Green Climate Fund (GCF) and the National Adaptation Fund for Climate Change to finance resilience efforts.

Vulnerable group-focused measures

- **Employment standards:** Develop and notify standard operating procedures (SOPs) for heat management across industries (such as construction), recognising ambient heat as an occupational hazard.
- **Workplace adjustments:** Implement mandatory measures during extreme heat periods (Danger/Extreme Danger Heat Index levels), including reducing workload, staggering work timings (shifting work towards early morning/night), and enforcing cooling breaks (for instance, 15-minute breaks every two hours for construction workers).
- **Support mechanisms:** Improve access to thermally comfortable housing, institutionalise the provision of cool clothing and hydrating food, and disburse dedicated fiscal support to compensate for lost livelihoods during heat emergencies.

The analysis emphasises that addressing heat vulnerability requires an active management approach that combines city-level infrastructural cooling strategies (like green-blue infrastructure and cool materials) with targeted, group-specific actions to safeguard the most exposed populations.

2

THE RATIONALE

Why study heat vulnerability in Delhi?

A decadal (2015-2024) analysis shows that 75.78 per cent of Delhi's area is heat-stressed; nearly 98.72 per cent has crossed the heat threshold at least once over the decade.

Delhi's green and blue infrastructure (natural wealth) has shrunk. Green cover has reduced from 25.36 per cent in 2014 to 14.14 per cent in 2024. Waterbody footprint has dropped from 1.25 per cent to 0.99 per cent. Land use transformation from agricultural to urban has led to this state of affairs.

Delhi is shifting towards a new and warmer normal, with increases observed in both annual average maximum and minimum temperatures over the past four decades, leading to warmer days and nights. The city's ability to cool down at night (diurnal cooling) has reduced by 9 per cent. This fuels a reliance on ACs, leading to the creation of localised heat hotspots and widens thermal inequity.

Exposure to high temperatures for longer periods not only increases the public health risk, but also heightens the impact of heat on the city's productivity and economy. Heat-related productivity loss could add up to 4.5 per cent of India's GDP – approximately US $150-250 billion – by the end of this decade.

Delhi has its share of risks posed by a warming world. Every summer, the city's 16.7 million people (Census 2011) sweat it out as temperatures soar steadily. In 2025, Delhi breached the 40°C mark early in the season on March 27; several heat wave periods followed. According to the IMD, a combination of high heat and extreme humidity in some of these periods meant the 'feels-like' temperature (the 'apparent' temperature, or how hot the weather actually feels to the human body) touched almost 52°C.[1]

The story has been the same for previous years as well, when temperatures stayed above the 40°C threshold for several days.

The crisis deepens when the heat begins claiming lives. Delhi witnessed 25 heat-related deaths in 2024, as per the Union Ministry of Health and Family Welfare (MoHFW); independent reports put this number at upwards of 55. According to these reports, people who succumbed to heat included a security guard, a woman labourer, and a car mechanic, among others[2] – a majority of the victims either worked outdoors or belonged to sensitive and vulnerable groups.

Is the national capital equipped to battle this phenomenon of acute heat which it is being unfailingly confronted with every summer? Can it build resilience and protect its vulnerable populations?

The compounding impact of heat

Residents of Delhi are now exposed to high temperatures for longer periods, both during day and night. This not only increases the public health risk, but also heightens the impact of heat on the city's productivity and economy. According to a 2022 World Bank report, up to 75 per cent of India's workforce – 380 million people – depends on heat-exposed work and labour, with nearly half of the country's economy coming from these jobs and professions.[3] The American management and strategy consulting firm McKinsey and Co estimates that heat-related productivity loss could add up to 4.5 per cent of India's GDP – approximately US $150-250 billion – by the end of this decade.[4]

Delhi, with a 3.7 per cent contribution to the GDP, could play a significant role in accelerating this state of affairs. The city needs to recognise this and plan for resilience – inaction would mean heavy economic losses.

Heat also has a compounding effect on the environment, climate and people. India's urban residents – and especially those in Delhi – have found a quick-fix for heat in air-conditioners: they have easier access to these cooling solutions and can

afford them. It is no surprise that AC ownership has tripled to 24 units per 100 households in the past decade in India, according to the *World Energy Outlook Report 2023*.[5] It is expected to triple further by 2050, and Delhi will have a major proportion of the users in this number.

This quick-fix solution has a double and deeper impact. Switching on an AC ejects heat into the ambient environment and heats up the air-shed of those who rely on the outdoor environment for cooling – essentially, it spurs cooling inequity.

Waste heat into the ambient environment also aggravates the urban heat island effect, and leads to more AC usage. A study by Centre for Science and Environment (CSE) titled *Power Pangs* shows that the city witnesses a higher night-time peak in electricity demand, primarily due to the use of ACs.[6] This cycle of heat rejection into the environment and increased AC usage disrupts the energy curve of a city and deters it from the path of its emissions reduction goals.

What makes the situation more alarming is the fact that Delhi's peak electricity demand is breaking records every summer. While it stood at an all-time high of 8,656 MW in 2024, the peak was projected to reach 9,000 MW in 2025, according to the State Load Dispatch Centre.[7]

A gap in understanding vulnerability and requisite action

The bigger the city, the deeper and vaster is its vulnerability. The challenge of rising heat and growing vulnerability requires not one, but many layers of safeguards. Delhi released its first draft Heat Wave Action Plan in 2023; this was notified in April 2024. While the plan officially announced the city's first steps in combatting heat, it spurred some action in terms of identifying departments and their roles and responsibilities throughout the year. Some solutions were suggested, including installation of cool roofs, building shelters and shade, drinking water stations, increasing plantations and maintenance of waterbodies, in addition to creating awareness about heat waves and emergency response.

But even after an updation in 2025, the plan misses out on a resilience strategy for vulnerable groups. The Delhi Heat Wave Action Plan 2025 identifies people from lower income groups, children, women, elderly, outdoor workers and the homeless, among others, as vulnerable groups in the city. This translates into a large chunk of Delhi's population – as high as 50 per cent – that is highly vulnerable to heat and does not have adequate means to adapt. This population is growing in numbers as well as exposing itself to rising heat, pointing to a growing public health threat.

These vulnerable groups are a crucial part of the city's economy and need more than an emergency response. In the absence of such action, Delhi will see more and more people – especially from these groups – being affected by, or in worst cases, succumbing to rising temperatures. The city needs a scientific and systematic response for its vulnerable populations.

CSE has conducted a **heat vulnerability assessment** for Delhi to inform the city's strategy towards bringing resilience. Delhi is rapidly changing its built form through self-construction, urban sprawl, greenfield development, redevelopment and re-densification; this is topped with excessive motorised transport, diminishing heat sinks and buildings and neighbourhoods that are not planned in a climate-responsive manner. This transformation is making the city lose its natural shield for heat and instead, adding to the urban heat island effect. The changing built form is trapping more heat.

If this status quo persists, the city will undergo irreversible damage, and its vulnerable communities will bear much of the brunt. Delhi's strategy must focus on building heat resilience for all, with priority action for those at highest risk from the rising heat.

3 THE METHODOLOGY

The CSE study begins by gathering evidence on the spatial disparity of heat seen in the city. Landsat data was analysed to identify heat spots and spatial changes in the natural heat sinks of the city.

A threshold of 45°C Land Surface Temperature (LST) was considered: areas which breached this value repeatedly for more than six years were identified as heat-stressed.

Next, the study identified and pinpointed the locations of vulnerable population groups. The spatial distribution of these groups was overlaid with heat-stressed areas.

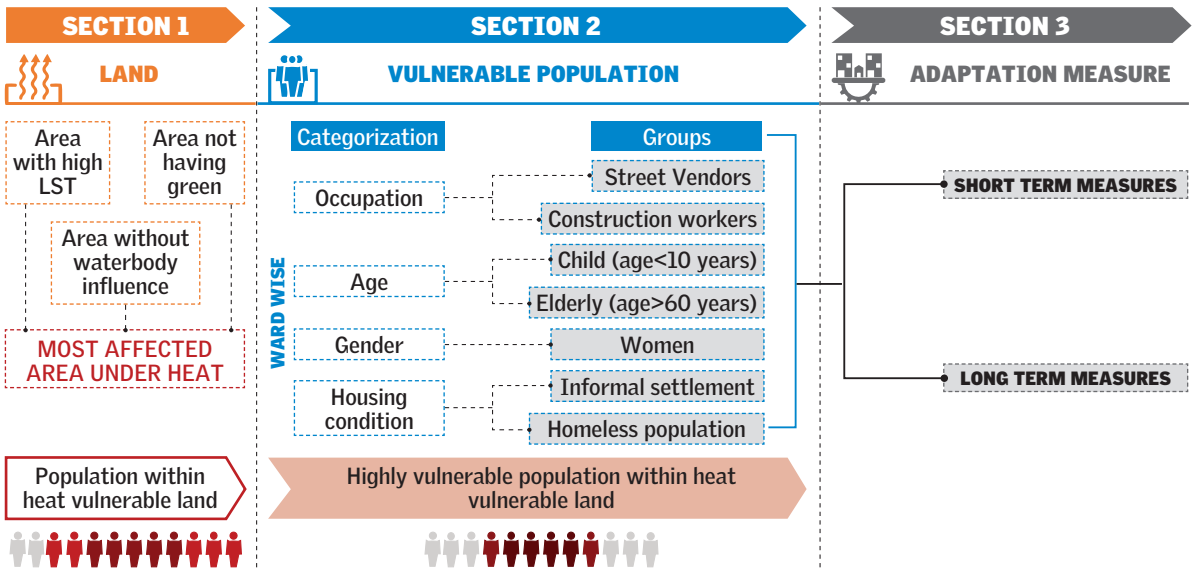
This has provided a granular understanding of Delhi's heat scenario and its impacts on people. The study and its assessment offers a base for planning and prioritising heat resilience measures in the city.

Delhi has witnessed rapid and uncontrolled urban growth over several decades. The city's population is projected to quadruple by 2031 to 24 million, according to the National Commission of Population.[8] In the meantime, the city has undergone tremendous spatial and socio-economic changes that may not be coherent in their response to the problem of rising heat. Delhi has several informal settlements, industrial zones, congested transport corridors, and areas with inadequate green and blue infrastructure that can heat up faster than others.

Therefore, the first step of this study was to build up the evidence for this spatial disparity of heat.

Using remote sensing, CSE teams analysed temporal Landsat data (for 10 years) to identify heat spots and spatial changes in the natural heat sinks of the city (*see Figure 1: Methodology for the study*). For identification of heat-stressed areas, temporal remote sensing data for the summer months (April-June) over a 10-year period (2015-2024) was sourced from Landsat 8/9 (Operational Land Imager and Thermal Infrared Sensor) for Delhi. This included Land Surface Temperature (LST) data products, from which LST values were estimated. A threshold of 45°C LST was considered and areas which breached this value repeatedly for more than six years were identified as heat-stressed.

Figure 1: Methodology followed for the study



Delhi is a city with numerous informal settlements, industrial zones, congested transport corridors and areas with inadequate green and blue cover – these locations can heat up much faster than others. The CSE study, therefore, begins with building up evidence for this spatial disparity of heat

CREDIT: CSE PHOTO LIBRARY

The next step was to assess the spatial extent of green and blue infrastructure in Delhi as key heat sinks. For this, the Normalised Difference Vegetation Index (NDVI) and Normalised Difference Water Index (NDWI) were used on satellite data. Data for two time points – 2010 and 2024 – was used to capture the changes over time. These indices were derived using band ratios from satellite imagery (Landsat series – Landsat 4/5 for 2010 and Landsat 8/9 for 2024). NDVI was calculated using the red and near-infrared (NIR) bands, and NDWI from the green and near-infrared bands using equations 1 and 2.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} \quad (1)$$

$$NDWI = \frac{(Green - NIR)}{(Green + NIR)} \quad (2)$$

Green: *Digital number (DN) associated with green band (0.52-0.60 μm); Band 3 for Landsat 8/9 and Band 2 for Landsat 4/5/7*
Red: *Digital number (DN) associated with red band (0.63-0.69 μm); Band 4 for Landsat 8/9 and Band 3 for Landsat 4/5/7*
NIR: *Digital number (DN) associated with near-infrared band (0.76-0.90 μm); Band 5 for Landsat 8/9 and Band 4 for Landsat 4/5/7*

This was followed by addressing the demographic disparity of heat. Prominent population groups that are sensitive to heat were identified in the context of Delhi and located in the city. These are children, elderly, women, construction workers, street vendors, informal settlement dwellers and homeless individuals.

The spatial distribution of these groups was obtained from different sources and overlaid with heat-stressed areas. This resulted in a cumulative ward-level vulnerability and granular understanding of Delhi's heat scenario and its impact on people. This assessment delivers the primary requisite for planning and prioritising heat resilience measures.

4

DELHI'S HEAT LANDSCAPE

Delhi is highly urbanised: 97.5 per cent of its people live in urban areas. The transformation from erstwhile agricultural to urban land uses has led to shrinking of natural heat sinks. Decadal analysis confirms that urban activities trap and emit heat. Delhi's Land Surface Temperature (LST) has reached 60.77°C in summer months in specific areas.

With over 75 per cent of the city being heat-stressed, the areas that are facing the brunt of the heat are commercial and institutional complexes, industrial areas, high-density low-rise residential colonies, and unplanned self-constructed colonies.

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56 per cent of Delhi's wards have more than 75 per cent of their area exposed to recurring heat stress; 17 have their entire area under heat stress – these localities include locations that are dense, low-rise settlements with little to no greenery.

Delhi's core area cools 3.8°C less than its peri-urban counterparts, causing heat stress to be retained round-the-clock in its dense concrete-heavy neighbourhoods.

Also see chapter highlights in Chapter 2 (The Rationale).

According to Census 2011, 97.5 per cent of Delhi's population lives in its urban areas. This means the city's land use pattern has transformed from agricultural to urban. Its natural sinks have shrunk, and its land uses and activities have started trapping and emitting heat. The decadal analysis conducted by CSE based on USGS Earth Explorer (Landsat 8/9) data confirms this, with the Land Surface Temperature (LST) reaching as high as 60.77°C during summer months in locations such as the Indira Gandhi International Airport, or in areas with unsown agricultural lands and barren stretches.

Neighbourhoods such as Bawana industrial area, Sultanpur Dabas, Puth Khurd, Anand Parbat industrial area, Khera Kalan, Mayapuri, Libaspur, Balli Maran, Mongolpuri industrial area Phase II and Mundka industrial area have emerged as heat spots. In addition, several residential areas are recording an LST ranging from 44°C to 50°C.

The Yamuna river remains a heat reliever for the city, with LST around it hovering at 33°C – but its impact is like that of a drop in an ocean.

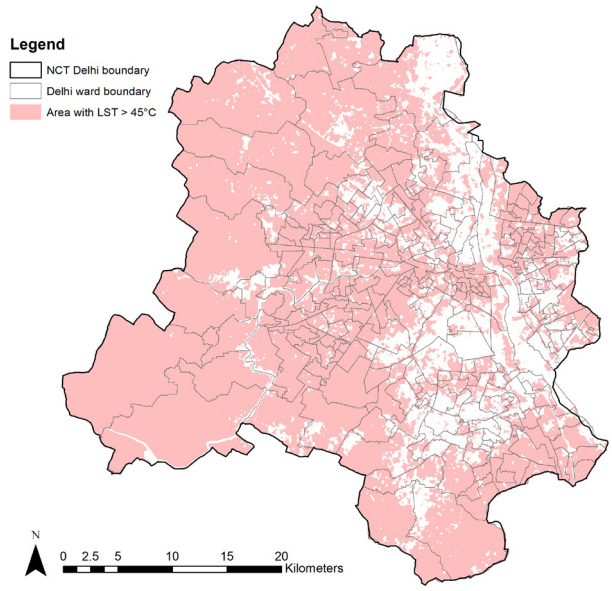
Who bears the biggest brunt?

A decadal (2015-2024) geospatial analysis based on USGS Earth Explorer (Landsat 8/9) and Census 2011 data reveals that 75.78 per cent of Delhi's area is heat-stressed (*see Map 2: Areas that have persistently crossed the heat stress threshold over the decade*). These areas include the walled city and its extensions, Karol Bagh, Kashmere Gate ISBT and its surroundings, and Connaught Place (inner circle) in Central Delhi. South-west, West and North-west Delhi – with dense neighbourhoods such as Uttam Nagar, Palam, Dabri, Najafgarh, Kanjhawala, Budh Vihar, Bawana and Narela – also feature among the hotspots.

What is building up the heat stress is unplanned self-constructed housing and buildings. In the north, this is happening mainly in Samaypur Badli, Bhalswa, Jahangirpuri, Burari and Azadpur industrial area. In the east, it is Shahdara, Bhajanpura, Karawal Nagar and Ghazipur industrial area; in south-east, there is Badarpur, Madanpur Khadar, Okhla industrial area, Tughlaqabad and Sangam Vihar. In the south of Delhi, there is Mahipalpur, Aya Nagar, Bhikaji Cama Place, AIIMS, RK Puram, Kotla Mubarakpur, Sarai Kale Khan, parts of Green Park and Greater Kailash, East of Kailash, and Lajpat Nagar along the Ring Road.

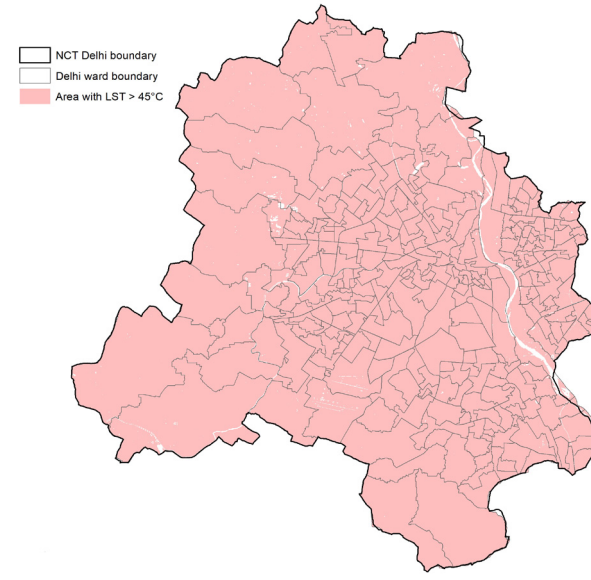
This shows that big commercial and institutional complexes, industrial areas, high-density low-rise residential colonies and unplanned self-constructed colonies face the brunt of the heat in Delhi.

Map 2: Areas that have persistently crossed the heat stress threshold over the decade



Source: CSE analysis based on USGS Earth Explorer (Landsat 8/9) data

Map 3: Areas that have crossed the heat stress threshold even once over the decade



Source: CSE analysis based on USGS Earth Explorer (Landsat 8/9) data

Interestingly, the newly built Bharat Mandapam and the redeveloped East Kidwai Nagar housing complex, as well as the World Trade Centre in Safdarjung and Netaji Nagar, are equally heat-stressed. As Delhi continues to redevelop, it will need to actively find ways to ensure that the new built-up fabric does not add to the entrapment of heat and instead, mitigates it.

Heat exposure for people living in heat-stressed areas is high compared to other neighbourhoods. These locations call for priority action. CSE's analysis also reveals that 98.72 per cent of Delhi's total area has crossed the heat threshold at least once over the decade (*see Maps 2 and 3: Areas that have crossed the heat stress threshold over the decade*).

A ward-wise breakdown reveals that 153 (56 per cent) wards of Delhi have more than 75 per cent of their area exposed to recurring heat stress (*see Map 4: Ward-wise coverage of heat stress in Delhi*). Out of the 272 wards in the city, 82 have more than 90 per cent of their area under heat stress (*see Graph 2: Wards with more than 90 per cent area under heat stress*). Of this, 17 have their entire area under heat stress. These include wards such as Turkman Gate, Ballimaran, Bazar

TOWARDS HOTTER NORMALS

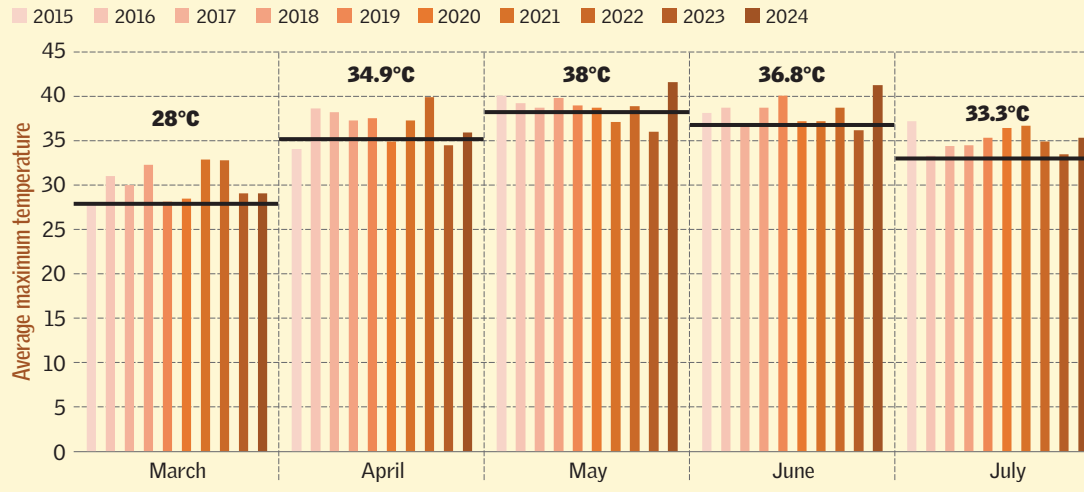
Delhi has been witnessing an increase in both annual average maximum and minimum temperatures over the past four decades.[9] This means warmer days as well as nights. CSE analysed the times Delhi breached its Normal Mean Maximum Dry Bulb Temperature and found that the city is shifting to a new and warmer normal.

Delhi departed from its normal on 42 out of 50 occasions in the summer months (March to July) over 2015-2024 (*see Graph 1: Month-wise breaches of the normal mean maximum dry bulb temperature during summer months over the past decade*).

Diurnal cooling is the ability of the city to let go of the entrapped solar radiation and cool down in the night. That ability has reduced by 9 per cent in Delhi, says a CSE analysis.[10] The city core cools 3.8°C less than its peri-urban counterparts. This retains heat stress round the clock, especially in dense concrete-heavy neighbourhoods.

Warmer nights push people to seek relief through air conditioners, which aggravate the ambient temperatures. A study in Beirut found that night-time temperatures rose by 4.4°C-4.7°C in neighbourhoods with high AC penetration.[11] The study also suggests that ACs become less effective during extreme day-time temperatures, leading to higher electricity consumption and greater emissions – pushing cities into a dangerous feedback loop of rising heat and energy demand. In Delhi, the growing dependence on ACs is fuelling localised heat hotspots and widening thermal inequity. While mechanical cooling benefits a few, the burden of added heat is shared by all.

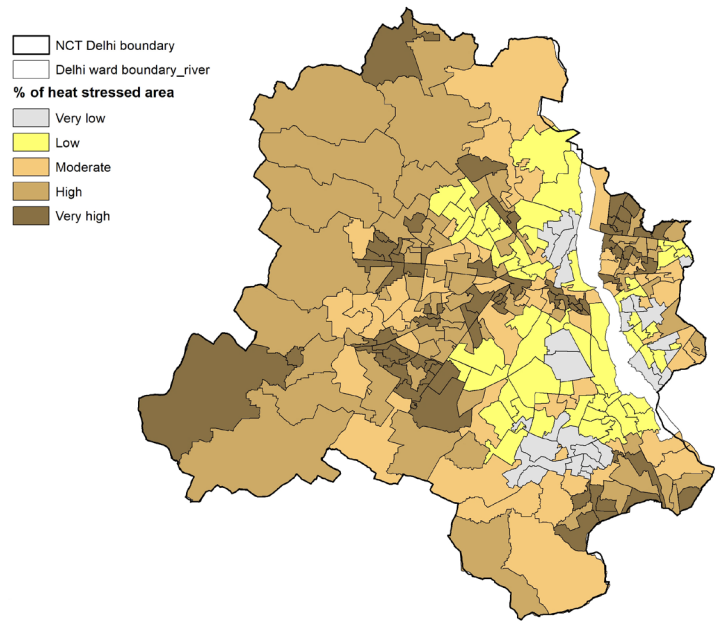
Graph 1: Month-wise breaches of the normal mean maximum dry bulb temperature during summer months over the past decade



Source: CSE analysis based on data compiled from Weather Underground

Note: Normal Mean Maximum Dry Bulb Temperature refers to the long-term average of the highest daily air temperatures recorded over a standard 30-year reference period

Map 4: Ward-wise coverage of heat stress in Delhi



Source: CSE analysis based on USGS EarthExplorer (Landsat 8/9) data

Sitaram, Baljit Nagar, Babarpur, Karawal Nagar East, Bindapur, Budh Vihar, Madhu Vihar, Shiv Vihar and Kirari Suleman Nagar, among others.

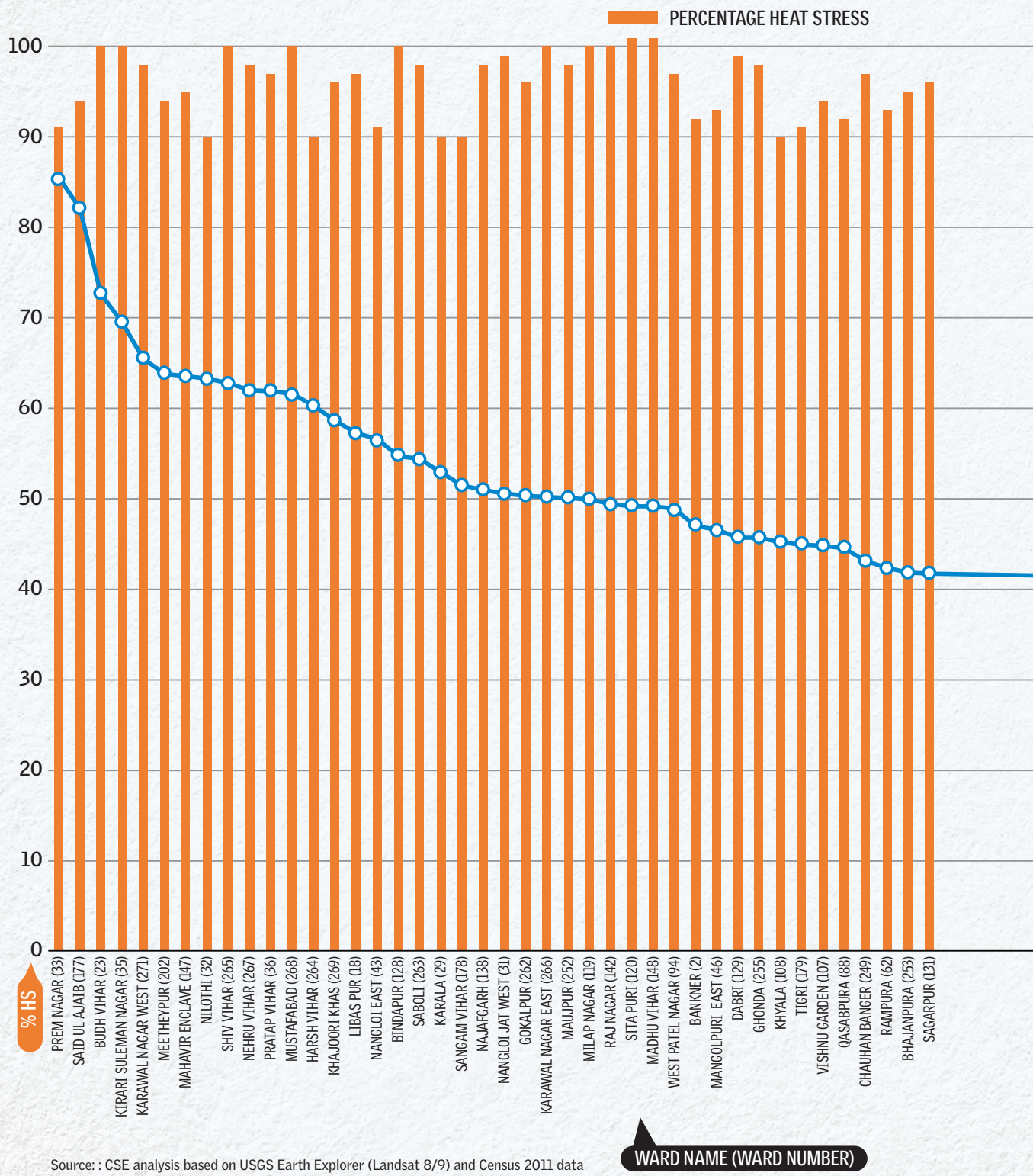
The remaining wards constitute nearly all of the walled city and its extensions, as well as several other peripheral wards. These wards house dense low-rise settlements – most of them unplanned urban extensions – with none-to-little greenery.

The mitigation opportunity

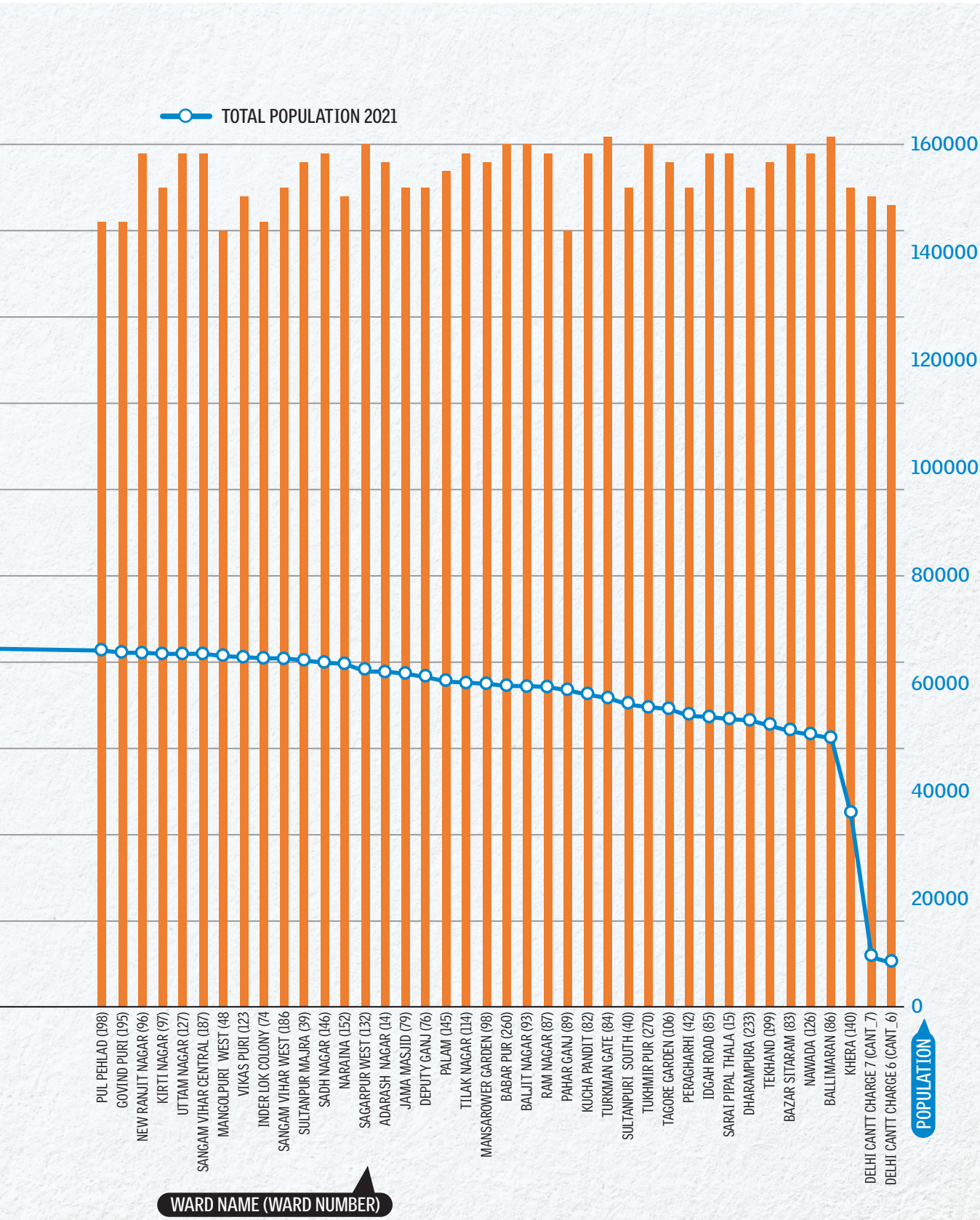
There are some pockets in Delhi that are able to remain cool for most of the summer months. Over the last decade, nearly 24 per cent area of the city has consistently remained below the heat stress threshold (*see Map 5: Areas that have consistently remained below heat stress threshold*) according to the analysis based on USGS Earth Explorer (Landsat 8/9) data. This area can be classified into two segments – 15 per cent and 9 per cent. While the former is the green-blue infrastructure of the city, the latter is the built-up fabric.

The cool built-up areas in Delhi include high greenery and low-density neighbourhoods like Lutyen's Delhi, Civil Lines and the Delhi Cantonment. These areas are also surrounded by ridges. While cities cannot afford to have the kind of sprawled development as is seen in these areas, the biggest takeaway here is the

Graph 2: Wards with more than 90 per cent area under heat stress



Source: : CSE analysis based on USGS Earth Explorer (Landsat 8/9) and Census 2011 data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140000
120000
100000
80000
60000
40000
20000
0
POPULATION
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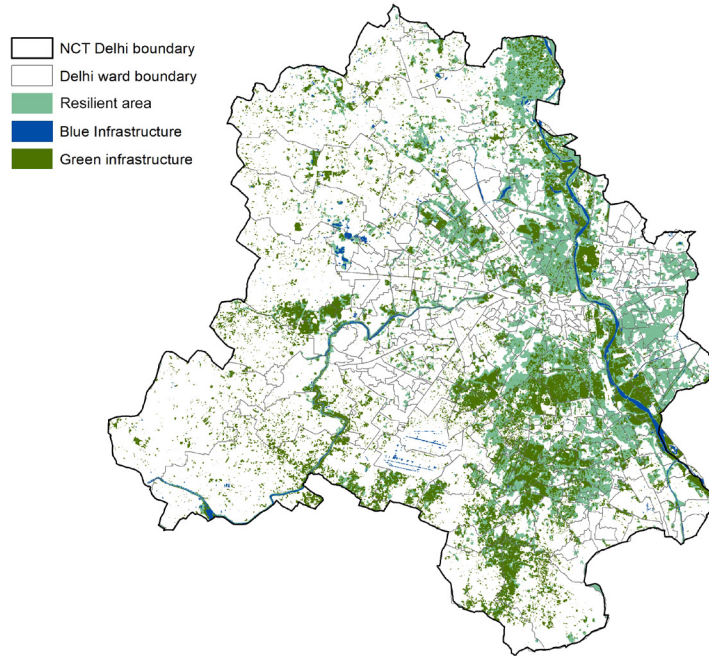
GOVIND PURI (195)
NEW RANJIT NAGAR (96)
KIRTI NAGAR (97)
UTTAM NAGAR (127)
SANGAM VIHAR CENTRAL (187)
MANGOLPURI WEST (48
VIKAS PURI (123
INDER LOK COLONY (74
SANGAM VIHAR WEST (186
SULTANPUR MAJRA (39)
SADH NAGAR (146)
NARAINA (152)
SAGARPUR WEST (132)
ADARASH NAGAR (14)
JAMA MASJID (79)
DEPUTY GANJ (76)
PALAM (145)
TILAK NAGAR (114)
MANSAROWER GARDEN (98)
BABAR PUR (260)
BALJIT NAGAR (93)
RAM NAGAR (87)
PAHAR GANJ (89)
KUCHA PANDIT (82)
TURKMAN GATE (84)
SULTANPURI SOUTH (40)
TUKHMIR PUR (270)
TAGORE GARDEN (106)
PERAGHARHI (42)
IDGAH ROAD (85)
SARAI PIPAL THALA (15)
DHARAMPURA (233)
TEKHAND (199)
BAZAR SITARAM (83)
NAWADA (126)
BALLIMARAN (86)
KHERA (140)
DELHI CANTT CHARGE 7 (CANT_7)
DELHI CANTT CHARGE 6 (CANT_6)
WARD NAME (WARD NUMBER)

Map 5: Areas that have consistently remained below heat stress threshold



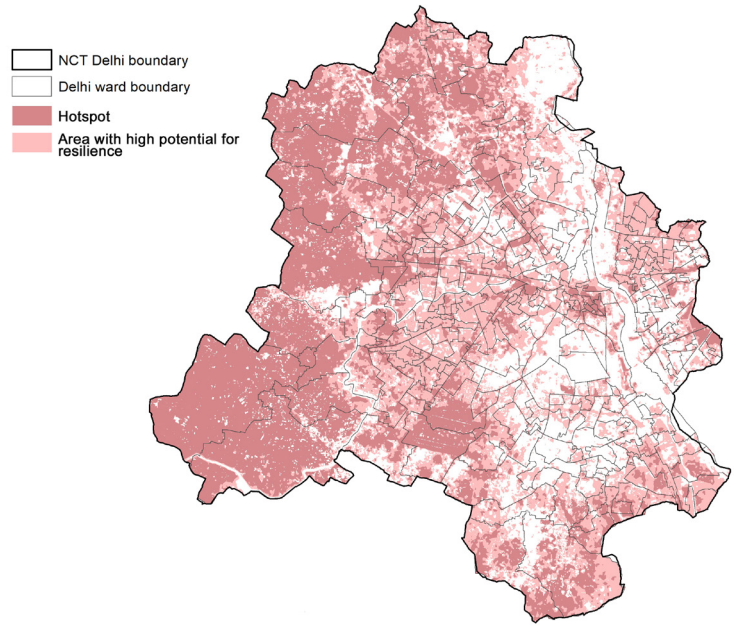
Source: CSE analysis based on USGS EarthExplorer (Landsat 8/9) data

enormous role that shading over paved surfaces can play. While these locations have less building footprints, they have substantial impervious areas under roads and pathways; yet they remain cool as trees shade all the paved areas.

There are also some planned residential colonies in Delhi that do not suffer from heat stress, mainly due to the presence of vegetation or 'greens'. These include parts of Model Town, Ashok Vihar, Shalimar Bagh, Rohini (early development phases), Vasant Vihar, Hauz Khas, Panchsheel, Chittaranjan Park, Greater Kailash 2, Pushp Vihar, Saket, Karkardooma, Mayur Vihar, Preet Vihar, Geeta Colony, Dilshad Garden and Delhi University, as well as those areas that are surrounded by green-blue spaces, such as Majnu ka Tila, Chhattarpur, etc.

These plotted row housing neighbourhoods do not face high land surface temperatures, but they suffer from poor ventilation and lack of daylight due to the increasing height of the buildings, which compromises their thermal comfort. With the increase in FAR (floor area ratio) in Delhi, these buildings – which started off with one-two floors back in the 1980s – now have four-five floors. This increasing density of habitation has consequences such as a rise in anthropogenic activities: more numbers of private motorised vehicles; and more air-conditioning. These

Map 6: Areas with high potential for heat resilience



Source: CSE analysis based on USGS EarthExplorer (Landsat 8/9) data

are bound to heat up the ambient air and increase thermal discomfort. Therefore, these neighbourhoods need to take measures to extend their thermal comfort hours and reduce the use of air-conditioning as much as possible. Retrofitting solutions for roofs, windows and shading devices can help achieve that.

The decadal analysis also shows that about a third of Delhi's area is able to withstand heat for some time in the summer. 35 per cent of Delhi's area does not get heat stressed until May. This is the area that has high potential for resilience. Nearly 36 per cent area is under heat stress in the month of April only which makes it a hotspot, according to the analysis based on USGS Earth Explorer (Landsat 8/9) data (*see Map 6: Areas with high potential for heat resilience*).

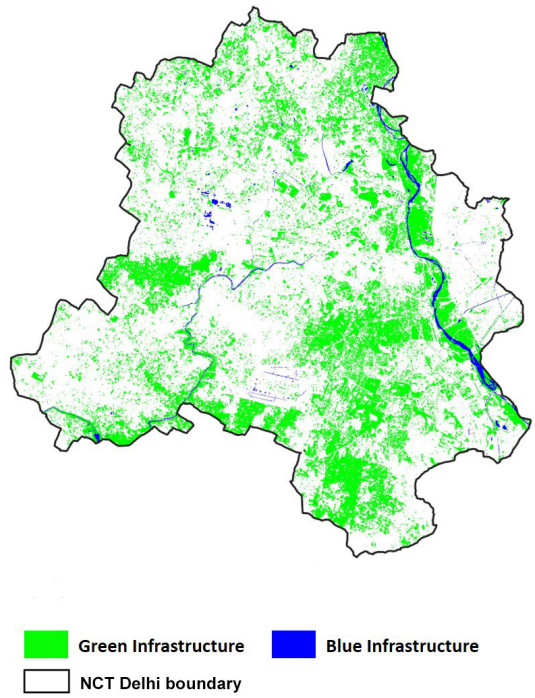
Areas that heat up in April include the IGI airport, many parts of old Delhi, unsown agricultural land and nearly all the industrial areas – these include Dwarka, Mayapuri, Anand Parbat, Lawrence Road, Wazirpur, Azadpur, Badli, Bawana, Narela, Puth Khurd, Alipur, Libaspur, Mundka and Ghazipur. Delhi has urban villages like Karala, Najafgarh and Chhawla that are unplanned settlements, growing rapidly and also heating up faster than the rest of the city. Such areas need cooling interventions on a priority basis. Innovative roof materials, low-carbon cooling systems and spot-cooling measures like shaded resting places for

workers can reduce both the heat build-up and impacts on the health of workers. Remaining areas which include the residential colonies, markets and institutional complexes demonstrate enormous opportunities to delay and reduce the heat build-up further. These are mostly planned areas that can be uplifted to withstand the heat even more. This will require a deep-dive assessment to find the best set of cooling solutions based on the context of the locality and urban morphology.

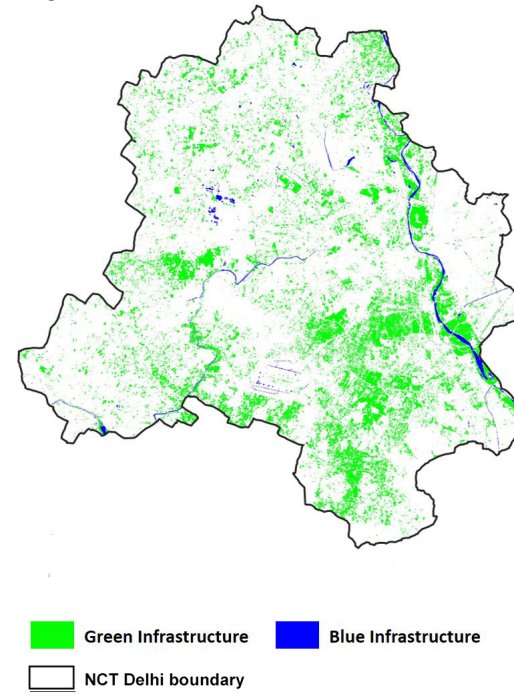
Losing shield, losing cool

Nature-based urban cooling is closely linked to the presence of, distance from, and quality of green and blue infrastructure. In Delhi, this infrastructure includes the river, canals, lakes, ponds, ridges, forests, a bird sanctuary, district parks, local parks and green belts. A decadal analysis shows that this natural wealth has shrunk from 25.36 per cent of the total green cover in 2014 to 14.14 per cent in 2024. Similarly, waterbody footprints in the city have reduced from 1.25 per cent to 0.99 per cent according to the analysis based on USGS Earth Explorer (Landsat 8/9) data (*see Maps 7 and 8: Green-blue infrastructure in 2010 and 2024*).

Map 7: Green-blue infrastructure in 2010



Map 8: Green-blue infrastructure in 2024



Notes: The extent of green and blue spaces was estimated using the Normalised Difference Vegetation Index (NDVI) and the Normalised Difference Water Index (NDWI). While these indices are reliable indicators, they may slightly overestimate actual on-ground conditions. For instance, NDVI accounts for all types of vegetated areas, including agricultural land with greens, fallow fields with grass, grasslands, shrubs, and trees.

Source: USGS EarthExplorer (Landsat 8/9)

This is consistent with the findings of the Central Empowered Committee (CEC) that over 308 hectare (ha) of the ecologically sensitive ridge area in Delhi has been encroached upon, and another 183 ha has been diverted for 'non-forestry purposes'.[12] Other major land use changes include conversion of agricultural land in Nangli Sakrawati and Fatehpur Beri for industrial development; some patches have also been converted into residential colonies, such as in Swaroop Nagar. The ridge area near the Freedom Fighter's Enclave has witnessed severe degradation, while construction activities around the Mukundpur metro depot are affecting the Dhirpur wetland. These changes reduce the ability of green-blue spaces to moderate local temperatures across the city.

Vegetation helps regulate surface and ambient temperatures through evapo-transpiration, where water stored in leaves is released as vapour; this restricts heat rise. Large-canopy trees intercept solar radiation and provide shade, reducing heat build-up on surrounding surfaces. The cooling effect from vegetation can extend up to 100 metre, with potential ambient temperature reductions of up to 5.7°C, according to a paper released by IWA Publishing, the UK-based international publishing firm.[13] In addition, green spaces contribute to carbon sequestration and improve air quality by trapping dust and pollutants that intensify urban heat.

Waterbodies act as thermal sinks and contribute to cooling through evaporation – heat is absorbed and used to convert water into vapour, preventing surface temperatures from rising. The resulting moisture helps cool adjacent areas up to 250 metre away and lower ambient temperatures by up to 5°C – according to the IWA paper.[14] Together, green and blue infrastructure reduce dependence on mechanical cooling and enhance resilience to rising heat.

It is important to note that it is not just the quantity of vegetation that matters, but its quality as well (*see Box: The quality of 'greens'*). A dense, shaded tree canopy has a far greater potential to cool the surrounding environment and exert its influence over a longer distance compared to low-lying surface greens or scattered shrubs. A CSE study demonstrates that a dense canopy cover can provide 10°C lower LST than a palm tree.[15]

Similarly, the size and depth of a waterbody determine the extent of its cooling impact – larger and deeper waterbodies are more effective in reducing temperatures and can influence areas several metres beyond their boundaries. These findings point to the importance of prioritising high-quality and effective blue and green infrastructure that is tailored to suit local site conditions to optimally increase thermal comfort and urban resilience.

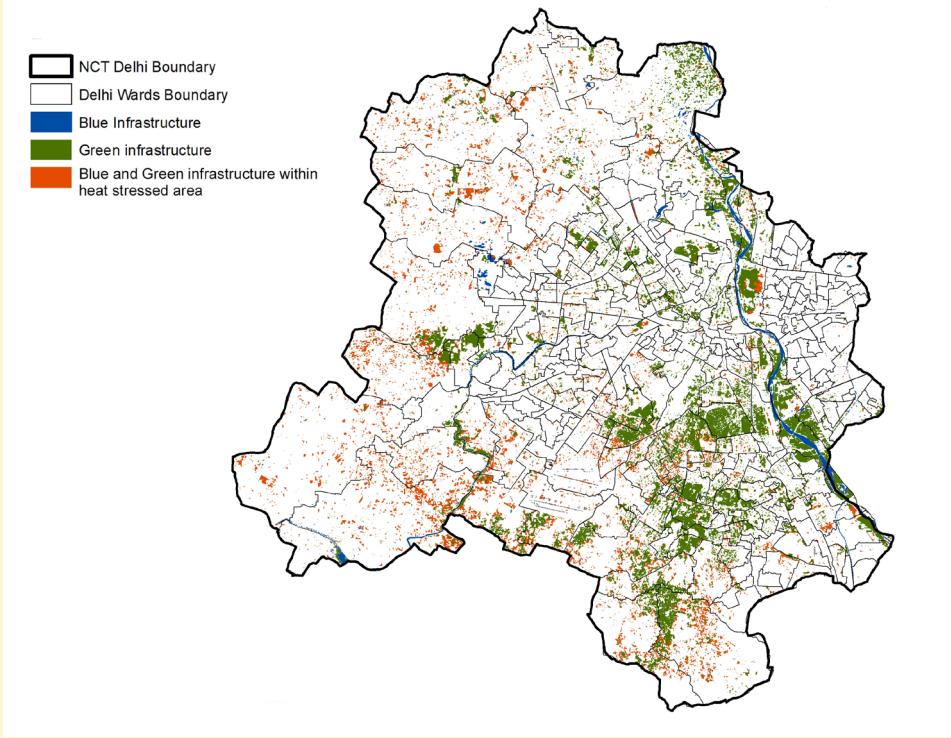
THE QUALITY OF 'GREENS'

Green and blue spaces are the primary safeguards against heat in the city. While there are several policies supporting and encouraging conservation and expansion of these spaces, there is little or no focus on their quality. The geo-spatial analysis in Delhi reveals that 35 per cent of the total green-blue spaces in the city are heat-stressed (*see Map 9: Heat-stressed blue-green areas*). This means they are not able to provide a cooling effect.

A majority of these areas comprise of grassed sites – such as near Rashtrapati Bhawan, India Gate and Golf Course (both in Lutyen's Delhi and Dwarka). Also included in this group are low-density green areas in self-constructed, low-rise housing blocks, dried up river catchments, and ridge areas.

Globally, codes have started addressing this concern by focusing on the quality of vegetation. For instance, Singapore has a metric that assigns weightage to grass (least), shrubs (medium) and trees (highest to varieties with wide canopy) in order to focus on the quality and functionality of greens as sinks. Delhi needs guidance on which species should be preferred for cooling the environment. While native species largely strengthen the defences against the harsh climate, codes and bye-laws need to integrate prioritisation of such species.

Map 9: Heat-stressed blue-green area



Source: CSE analysis based on USGS Earth Explorer (Landsat 8/9) data

5

EXPLORING VULNERABILITY

Extreme heat does not affect everyone equally. Vulnerability is linked to physiological disadvantages (children, elderly, women) or lack of resources and locational/ occupational disadvantages (poor, homeless, outdoor workers).

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80 per cent of Delhi's workforce is employed in the informal sector; 75 per cent of the city's women workers are in this sector. The economic cost of heat stress is severe: the World Bank says India will lose 34 million jobs due to heat stress-linked productivity decline.

The CSE study finds that every vulnerable group is living or working in high heat-stress zones. For example, construction workers face high occupational vulnerability – 92 per cent of construction projects are located in areas where Land Surface Temperature (LST) has exceeded the 45°C threshold at least once between 2015 and 2024, and 77 per cent are in areas witnessing recurring extreme heat.

About 84 per cent of the 643 mapped marketplaces – including all the major mandis – are located in areas experiencing recurrent heat stress: these are the workplaces of Delhi's street vendors. Most of the city's informal settlements are located in heat-stressed localities.

CSE simulated microclimate interventions at select high-footfall public places, revealing substantial cooling potential. Measures like planting dense-canopy trees, installing lightweight artificial canopies and replacing hard surfaces with high-reflectance pavers brought down LST.

Extreme heat does not affect everyone in the same degree or manner. There are certain demographic groups that are more vulnerable to high temperatures than others due to physiological disadvantage or co-morbidities. They include children, elderly and women. There are others who are less privileged to cope with the rising heat and lack resources to adapt – such as access to basic services and active cooling solutions – or have a locational and occupational disadvantage. This group includes the poor, homeless and people who work outdoors like construction workers, street vendors, artisans, automobile mechanics, ragpickers, sanitation workers, gig workers, etc.

These population groups constitute a substantial proportion of urban economy, especially in large cities. For instance, 80 per cent of the workforce in Delhi is employed under informal arrangements, according to an analysis conducted by the global network WIEGO (Women in Informal Employment: Globalizing and Organizing). This analysis was based on the 2017-18 Periodic Labour Force Survey data compiled by the National Sample Survey Organisation.[16] In Delhi, 75 per cent of the women's workforce is in the informal sector; 27 per cent of these women work as street vendors or market traders.[17]

No wonder the World Bank estimates that India will lose 34 million jobs from heat stress-linked productivity decline.[18] McKinsey and Co places the loss due to heat and humidity at 4.5 per cent of India's GDP – around US $150-250 billion by the end of 2030.[19] This raises the stakes for public health and socio-economic well-being for a major chunk of Delhi's population.

CSE has identified seven population groups for this assessment of health and socio-economic impacts of heat on people in Delhi. Children, elderly and women possess physiological vulnerability, while women also demonstrate a gender-based vulnerability – according to the IPCC's *Sixth Assessment Report*. Construction workers and street vendors are exposed to ambient heat due to the nature of their work and, therefore, face occupation-based vulnerability. Residents of informal settlements or JJ (*jhuggi-jhopri*) clusters in Delhi and the homeless are vulnerable because they lack the resources (climate-appropriate housing or cooling devices) to adapt.

This ward-level assessment also offers an approximation of how many individuals from each group are located in heat-stressed areas in Delhi. This spatial distribution gives both – the concentration of specific groups in a ward, as well as a ward-wise cumulative overview of all the groups combined. The analysis has the potential to

lay the foundations for a demographic group-targeted and locational response to combat urban heat.

Occupation-based vulnerability: Construction workers

The nature of the work done by construction workers includes strenuous activities, most of which take place outdoors or in semi-exposed settings, often under direct sunlight. Their surroundings also involve surfaces that trap heat, such as concrete, metal, sand and asphalt and amidst exhausts spewing out from heavy machinery and equipment. The use of safety and personal protective equipment hinders heat dissipation in conditions of high heat and humidity and adds to the heat stress of these people.

The adaptive capacity of construction workers is usually weak, as they live at or around construction sites. These sites lack adequate shade, rest areas and access to safe water and sanitation. Their accommodation involves temporary, congested and unventilated dwellings often made from tin sheets and other makeshift materials that are barely able to ward off heat. A lack of awareness about heat waves, related protocols and how to recognise early symptoms of heat stress or heat-related illnesses adds to their thermal discomfort.

Virender Singh / https://www.istockphoto.com

The adaptive capacity of construction workers is usually very weak, as they live at or around construction sites in temporary, congested and unventilated dwellings made of tin sheets and other makeshift materials

In India, despite growing mechanisation, much of the construction work remains manual. The use of heavy machinery such as booms, loaders, excavators or other power tools is limited to large-scale projects. Strenuous manual work under heat exposure dehydrates a worker; it can lead to loss of electrolytes, increase muscle strain, and risk muscle breakdown and heatstroke in extreme cases, especially when recovery time and conditions are poor.

The action so far

The labour department of the government of Delhi announces precautions and arrangements when the IMD predicts heat waves. In 2024 and 2025, the department issued an order based on the Delhi Heat Wave Action Plan, with its focus limited to provision of drinking water, proper ventilation and cooling devices at workplaces; fire safety measures; avoiding outdoor work and work in peak heat hours (12-4 PM); and preparing emergency kits (ice packs, ORS, etc) for construction workers.[20,21] But the city needs to do much more (see Annexure).

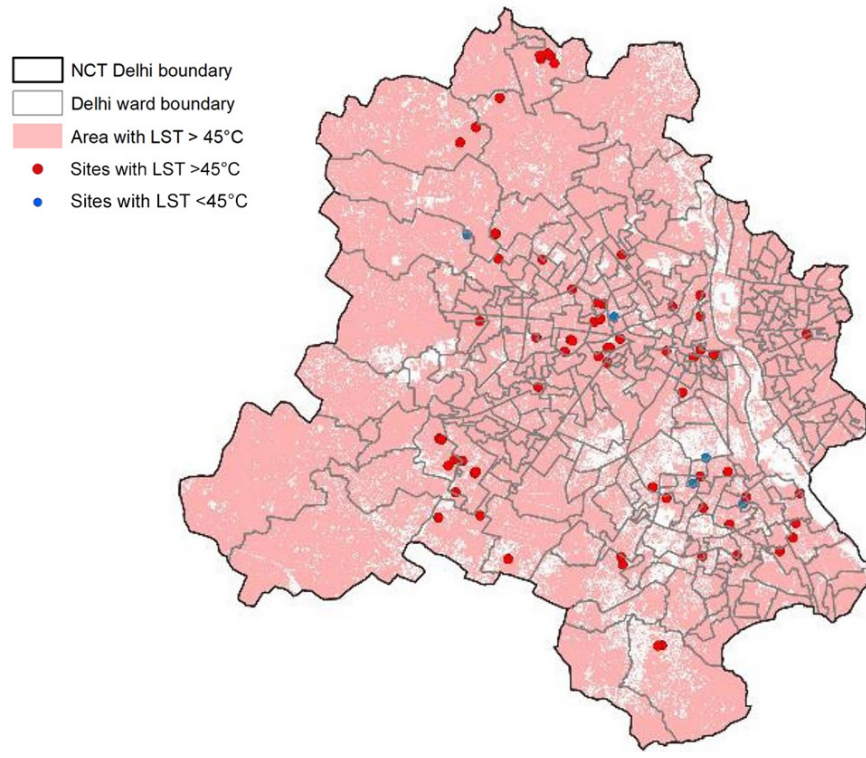
Delhi is dominated by self-constructed housing, which includes small- to medium-scale projects. The number of these projects is very high. At the same time, the city is undergoing massive redevelopment and constructing gigantic infrastructure projects such as the Delhi Metro and the regional rapid rail connecting cities of the National Capital Region. Just the Central Vista and the redevelopment projects of older colonies (Nauroji Nagar, Sarojini Nagar, Netaji Nagar, etc.) undertaken by the Central Public Works Department (CPWD) and NBCC India cover upwards of a sprawling 5.5 million sq m. According to the Delhi Building and Other Construction Workers Welfare Board, there are 5.5 lakh (0.55 million) registered workers as of 2020.[22]

Naturally, such large-scale projects involve a huge army of construction workers. A registration drive carried out during the construction ban under Delhi's air pollution emergency has revealed that the city has about 90,000 construction workers.[23] The drive was conducted to find out the number of beneficiaries for the financial assistance announced by the Delhi government to make up for the livelihood loss due to the ban; similar support is needed for livelihood loss due to heat.

CSE's on-ground assessment

CSE investigated ongoing construction in Delhi for a closer-to-ground overview of this demographic group. There are 79 active construction sites in the city, says the Real Estate Regulation Authority (RERA) database. Spatial overlay of these projects with heat-stressed areas revealed that 92 per cent of them are located in areas where

Map 10: Construction sites located in areas which saw LST above 45°C at least once during 2015-24

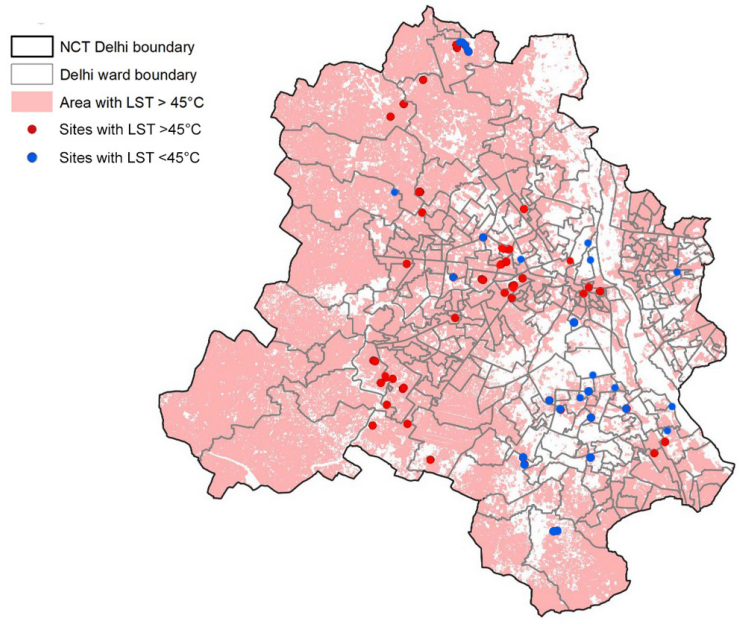


heat crossed the stress threshold at least once in the summer months between 2015 and 2024 (*see Map 10: Construction sites located in areas which saw LST above 45°C at least once during 2015-24*). Seventy-seven per cent of these sites are located in areas witnessing recurring extreme heat according to the analysis based on USGS Earth Explorer (Landsat 8/9) and RERA data (*see Map 11: Construction sites in areas witnessing recurring LST above 45°C during 2015-24*).

To add to this, 43 sites with a total built-up area of 1.6 million sq m are estimated to host nearly 80,000 workers. Nearly 7.4 million sq m of ongoing and planned construction related to the redevelopment projects (AIIMS and Netaji Nagar) and GPRA (General Pool Residential Accommodation) colonies is estimated to engage at least three lakh (0.3 million) construction workers spread across the duration of the projects. This estimate is based on an assumption that one worker is required for every 20-25 sq m of building construction.

According to ward-wise distribution, 48 municipal wards in Delhi host one or more active construction sites. Kakraula and Narela had the highest number, with five

Map 11: Construction sites in areas witnessing recurring LST above 45°C during 2015-24



projects each, followed by Karam Pura (four projects); Chandni Chowk, Punjabi Bagh, Matiala, Shakur Pur, Sahibabad Daulat Pur and Bawana had three each. Wards such as NDMC Ward 5, Pusa, Bhati, Sarita Vihar, Rampura, Bijwasan, Kishangarh and Safdarjung Enclave reported two projects each as per the RERA data. The majority of these wards fall either at the periphery or the dense core of the city – areas which are facing recurrent heat stress.

The peripheral areas in Delhi are devoid of cheap housing options, public transport connectivity and other basic social and physical infrastructure required by a household. This compromises their adaptive capacity. At the same time, wards like Kakraula and Narela are undergoing major construction due to the urban expansion projects of the Delhi Development Authority (DDA) – these include the Narela sub-city, the Najafgarh drain project, Atal Park and the Sahibi riverfront, and some key mobility corridors. This translates into high concentration of workers for a long time (this work is expected to continue for some years). Such locations demand priority attention.

Occupation-based vulnerability: Street vendors

Street vending is an essential part of urban India and its culture, and contributes to subsidised urban living. Daily household needs such as fruits, vegetables etc are met through street vendors. Shopping streets (often identified with squatters),

weekly markets, local vendors who sell on mobile carts or stationary set-ups, licensed (by the municipality) hawkers (*tehbazaari*), occasional vendors (fairs and festivals) etc are some of the examples of street vending, of which Delhi has its fair share.

But street vending comes at a cost. Vendors have to work for prolonged periods (10-14 hours), often under direct sun, on pavements or asphalt that retain heat and in crowded places regardless of the temperature outdoors. They have limited access to safe drinking water, sanitation, shade, resting areas and cooling solutions.

On days that are excessively hot, their business suffers as the number of buyers of their goods tends to dip. This impacts their livelihoods. High exposure combined with weak adaptive capacity leaves street vendors vulnerable to heat. This exposes them to a double risk – of heat-related illnesses as well as low earnings.

The website of the New Delhi Municipal Corporation (NDMC) displays a list of 741 verified hawkers as of 1999; the number of hawkers registered with the Municipal Corporation of Delhi (MCD) is not even available in the public domain.[24] But a survey done by WIEGO says there are an estimated 500 weekly markets in Delhi with not less than 1.1 lakh (0.11 million) vendors.[25] Another estimate places the number of street vendors in Delhi at three lakh (0.3 million), of which one-third are women.[26] The majority (82 per cent) of these vendors sell perishable goods which are prone to wastage and losses during high heat episodes.

Delhi is home to Asia's largest agricultural produce market at Azadpur. According to the Delhi Agricultural Marketing Board, there are six more large-scale markets – *mandi*s – in the city.[27] These include Ghazipur, Keshopur, Mehrauli, Najafgarh, Narela and Shahdara. While Azadpur is estimated to employ nearly 50,000 women and men, other markets account for another 2,500 workers (approximately).[28] In addition to these, there are casual labourers as well in this markets.

A lot of street vending activity is concentrated around these *mandi*s. Activities in and around these markets include carrying, loading, unloading, stacking and weighing heavy sacks (50-90 kg) of produce from early morning to late evening. These activities are physically demanding, for which the workers receive low wages in return. Street vendors purchase and load produce from these markets and sell it throughout the day. The Azadpur market alone sees over one lakh visitors every day all the year round.

The action so far

Legal recognition to street vendors came only in 2014, through the Street Vendors (Protection of Livelihood and Regulation of Street Vending) Act. This was followed by the Delhi Street Vendors (Protection of Livelihood and Regulation of Street Vending) Rules, 2017 and the Government of National Capital Territory of Delhi Street Vendors (Protection of Livelihood and Regulation of Street Vending) Scheme, 2019.

Delhi's street vendors form a substantial community which faces risks from urban heat. This makes a case for addressing prolonged heat exposure and adaptive capacity of these workers and also exploring microclimate enhancement for thermal comfort.

CSE's on-ground assessment

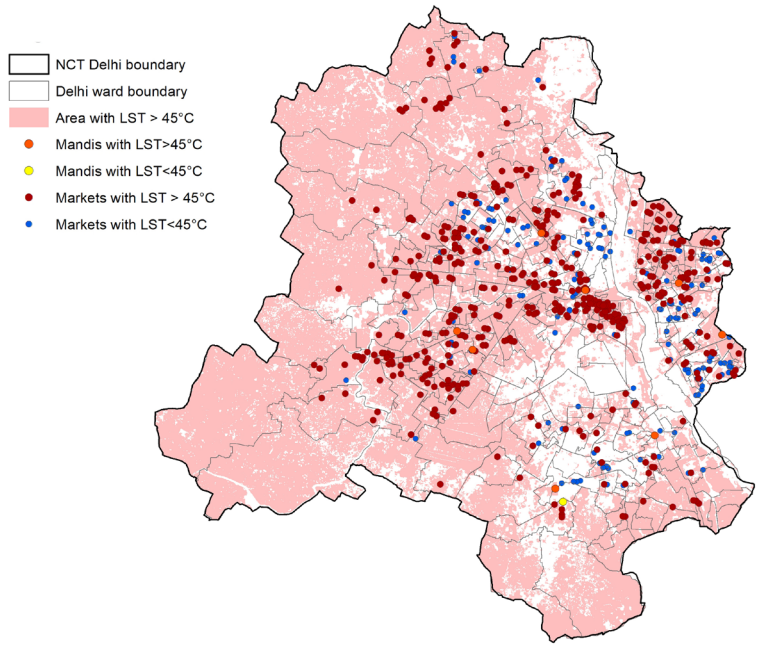
CSE mapped 643 marketplaces across Delhi, including weekly markets, *mandi*s for grains, fruits and vegetables, and meat and fish markets using data from independent research and surveys. Of these, 542 markets (around 84 per cent) are located in areas experiencing recurrent heat stress (*see Map 12: Marketplaces facing recurrent heat stress: Regions exceeding the 45°C LST threshold in six or more years*). All the major *mandi*s are also affected by recurrent heat stress.

The CSE assessment also shows that 602 markets (about 94 per cent) are located in high heat areas where LST exceeded 45°C at least once between April and June from 2015 to 2024 (*see Map 13: Marketplaces where LST surpassed the 45°C threshold once during 2015-24*).

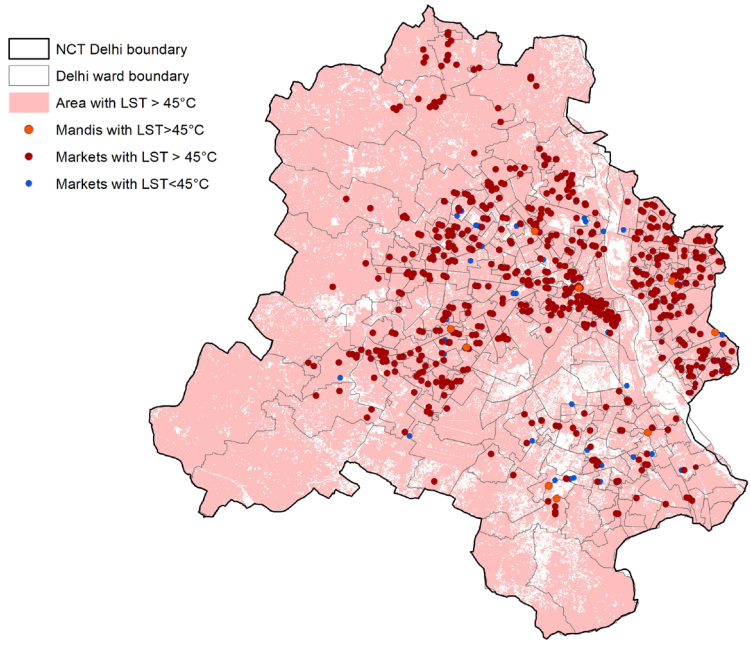
Ward-level distribution revealed that the highest concentration of street vending spots is in Burari (11 markets), Ballimaran (10) and Malkaganj (10). These are followed by Deputy Ganj, Alipur and Rohini North with nine each; Rohini and Khichripur with eight each; and Chandni Chowk, Minto Road, Bazar Sitaram, Jama Masjid, Matiala, Roshanpura, Vijay Vihar, Dhir Pur and Narela with seven spots each.

These wards include congested old Delhi neighbourhoods and transitioning peripheral areas. It is important to note that an area like Chandni Chowk, one of the oldest and busiest commercial hubs in India, with its mixed-use retail and wholesale activity and tourism, is also under heat stress. These areas need to be prioritised for heat-related action.

Map 12: Marketplaces facing recurrent heat stress (exceeding the 45°C LST threshold in six or more years)



Map 13: Marketplaces where LST surpassed the 45°C threshold once during 2015-24



Source: Created by CSE using data from Women in Informal Employment: Globalizing and Organizing, City Food Research Group; and USGS Earth Explorer (Landsat 8/9)

MICROCLIMATE MANAGEMENT THROUGH URBAN DESIGN: CHANDNI CHOWK, CONNAUGHT PLACE AND LAJPAT NAGAR

Rising heat is making it impossible to be outdoors, especially during the day time in summers. Heat-stressed areas of Delhi include several markets, shopping streets, commercial and tourist spots, transport hubs, traffic junctions, recreational places and religious sites. These are locations with high footfalls, where people not only pass through but also gather around, wait, socialise and eat. These are also places where street vendors, daily wagers, urban poor and commuters spend a lot of their time and are quite exposed.

To understand the outdoor heat threat in such areas, CSE simulated microclimate conditions at three prominent public places in Delhi: Connaught Place, Chandni Chowk and Lajpat Nagar. The impact of cooling measures like increased shading – both vegetation-based and artificial canopy-based – use of reflective materials, water elements and improvements in overall greenery was studied to inform evidence-based decision-making.

The selected locations are some of the major commercial hubs of Delhi. While Chandni Chowk is a tourist and commercial destination, the selected spot in Connaught Place has a temple complex: both the locations have been redeveloped recently. Lajpat Nagar is representative of Delhi's busy shopping streets and markets. All these locations are affected by heat stress.

The simulations revealed that trees reduced the land surface temperatures at these locations by 6-15°C: canopy density is the critical factor here. Dense-canopy trees achieved reductions of 9-15°C, while less dense canopies lowered temperatures by 6-8°C. But trees can take many years to grow. In such cases, lightweight artificial canopies can provide an interim solution. Use of such lightweight polyvinyl chloride (PVC) canopies – tensile structures which use fabrics stretched over steel or cable-supported frames – has brought down LST by 12-21°C.

Wooden frames or trellises covered with climbing vegetation are also a good solution: they not only provide shade, but also add to the greenery. In sensitive areas such as heritage zones, collapsible or movable canopies such as retractable frames or inverted umbrella structures can be used to provide shading during peak hours while maintaining an unobstructed cityscape at other times. Additionally, solar panels can be strategically deployed as shading devices in spaces such as parking areas, thereby combining comfort with renewable energy generation (*see photos on pages 43-44*)..

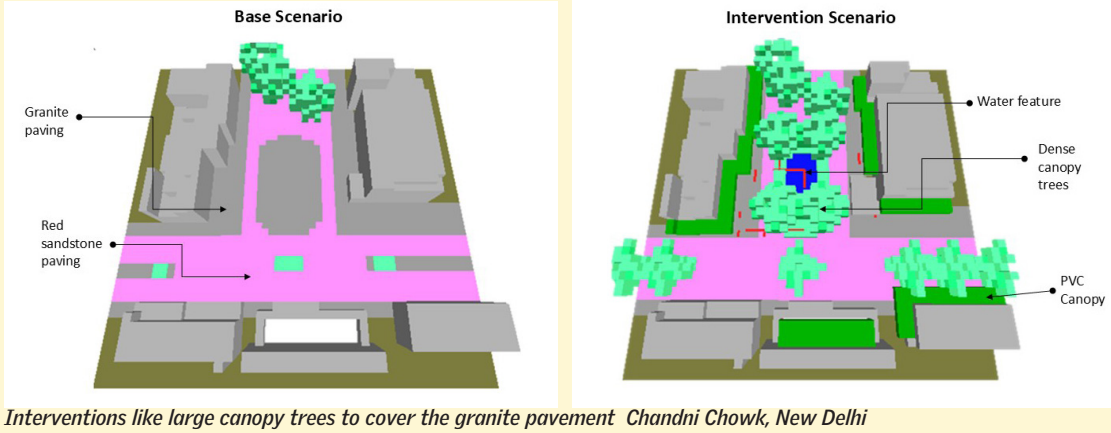
Vegetation such as grass and shrubs have improved the overall thermal comfort. Areas away from these pathways and covered in shrubs were found to be 2.5-3°C cooler (air temperature). Grass reduced this temperature by 2°C. The cumulative effect of vegetation and water features like fountains and small artificial ponds has made the ambient environment 2-3°C cooler. Vegetation contributes by shading surfaces and releasing moisture through evapotranspiration, which cools the surrounding air.

The other prominent interventions have targeted the hardscape material at all the locations. All three locations have seen abundant use of concrete, granite, sandstone and dark asphalt, which has led to LSTs as high as 57-61°C on a hot May afternoon. When the hard surfaces were replaced with high-reflectance pavers, LSTs came down by 5-9°C.

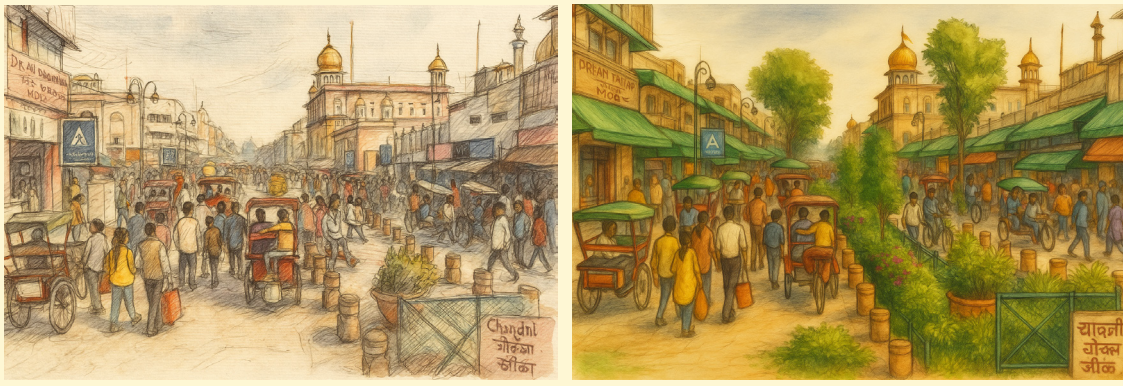
Water features effectively lower the temperatures through evaporation. As water evaporates, it absorbs heat from the surrounding environment, creating localised cooling. At the same time, the high heat capacity of water helps slow down the temperature rise compared to paved surfaces. This reduces heat build-up during the day.

The analysis also showed that when cooling strategies were combined, the benefits amplified. Clusters of canopy trees or compound shading created by trees and lightweight canopies together brought the LST down by a whopping 20°C. Pairing tree shade with reflective paving also proved effective, bringing down temperatures by as much as 15ºC compared to single interventions.

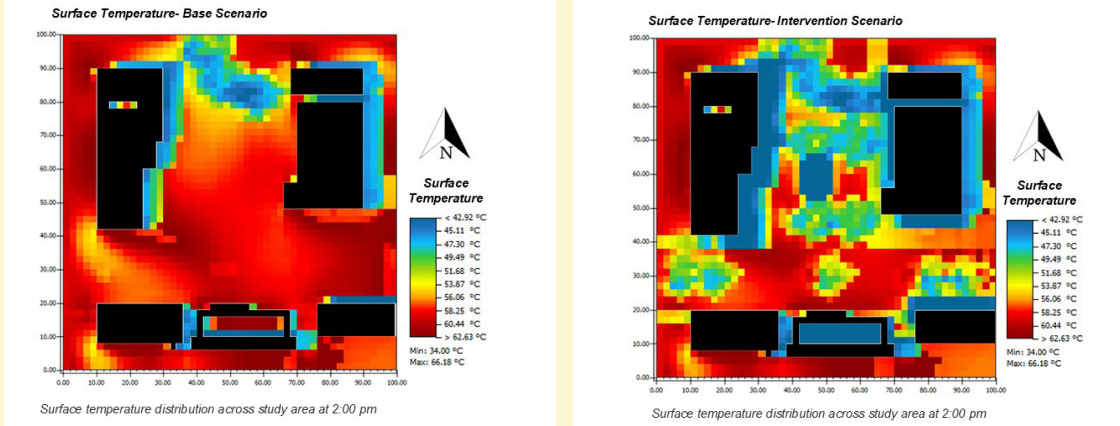
As cities heat up, they have started showing the need to regulate ambient heat and make outdoors thermally comfortable. High temperatures, combined with unconducive materials and design, is adding to the problem and forcing people indoors. Places with high footfalls need measures that do not entrap the heat falling on the surface, and keep the microclimate cool on priority. As Delhi is currently investing in the improvement and development of non-motorised infrastructure, this offers an opportunity for making the city heat-resilient as well.



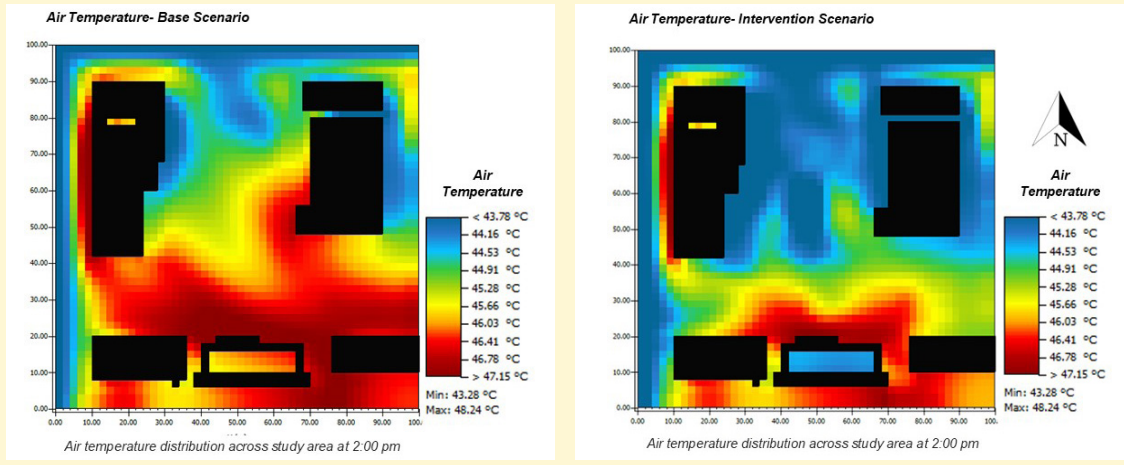
Interventions like large canopy trees to cover the granite pavement Chandni Chowk, New Delhi



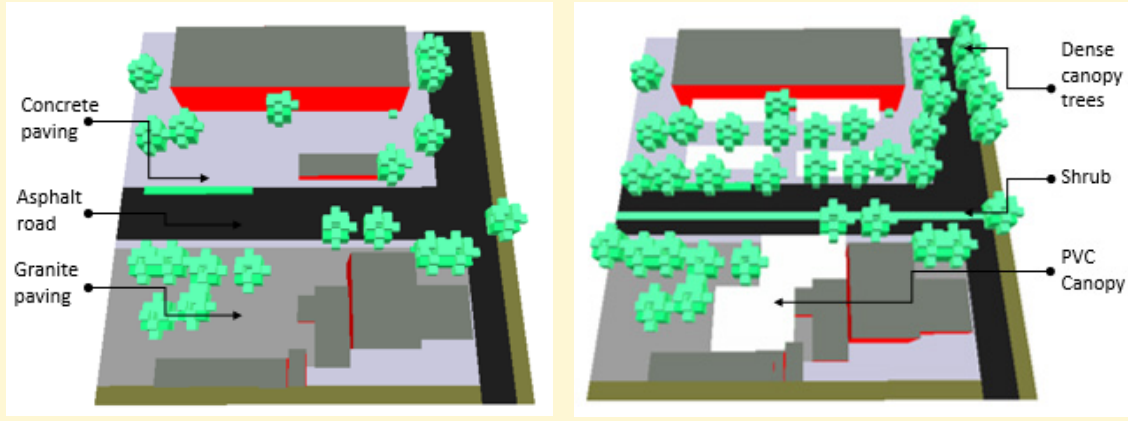
Chandni chowk before (left) and after (right) cooling interventions



Surface temperature distribution across study area, Base (left) Vs Intervention Scenario (right) in Chandni Chowk, Delhi

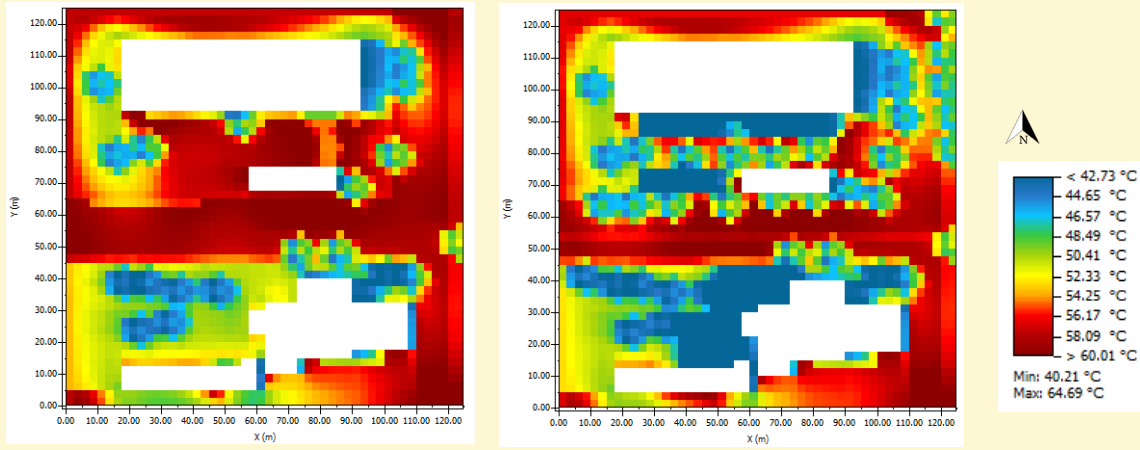


Air temperature distribution across study area, Base (left) Vs Intervention Scenario (right) in Chandni Chowk, Delhi

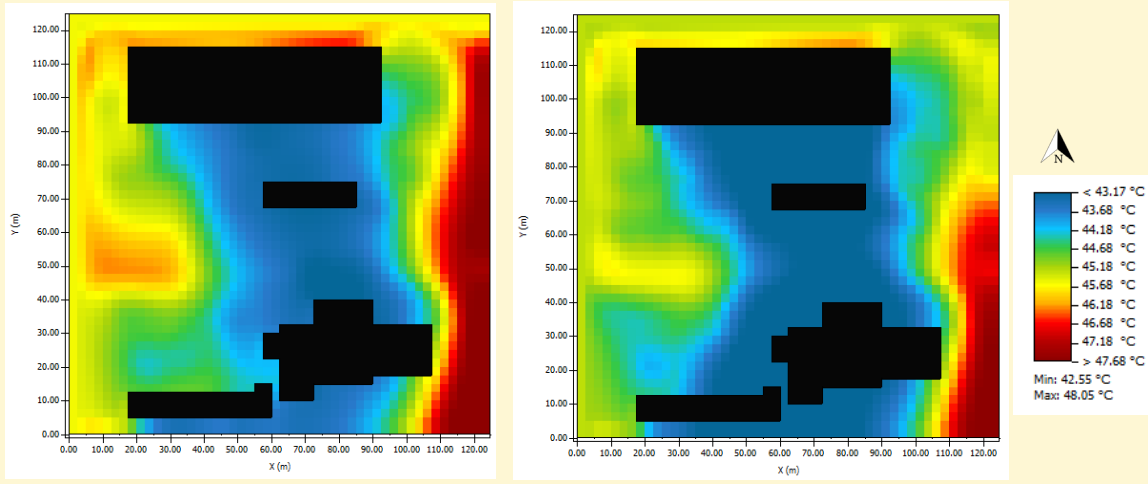


Connaught Place before (left) and after (rigtht) interventions like shrubs, dense canopy trees and PVC canopy at the paved area near Rajiv Chowk metro station exit

Connaught Place before (left) and after (right) cooling interventions



Surface temperature showing drastic reductions around interventions at Connaught Place site



Air temperature distribution across study area Connaught Place, New Delhi

Different approaches for shading (left) Tensile fabric canopy roofed car park at Mysuru, Karnataka (right) Metal frame with wooden trellis allowing vegetation to grow over

Retractable umbrella canopies in an educational institute in Australia (top), Solar panels used as shading devices over car parking (bottom).

Source-https://www.aakrutitenso.com/tensile-fabric-canopy-mysore-karnataka.htm, https://iaa.textiles.org/awards/147093-2/, https://www.linkedin.com/pulse/solar-panel-shaded-parking-lots-evs-andrew-j-frankel

Resource-poor and vulnerable: Informal settlement dwellers

Delhi has more than three lakh (0.3 million) households living in informal settlements (jj *bastis*), according to the Baseline Report of the draft Master Plan for Delhi 2041.[29] These settlements are – typically – overcrowded, densely packed with poor ventilation and with dwellings made from heat-retaining materials such as tin sheets, tarpauline or other makeshift materials. They are often located in marginal areas without any tree cover or open spaces, which adds to the heat build-up.

Households in these settlements do not have access to safe water and sanitation; this compromises their adaptive capacity. In the case of Delhi, such settlements rely on community water connections or tankers for water. As of 2022, the Delhi Urban Shelter Improvement Board (DUSIB) has created 630 community toilets (nearly 21,000 seats) under the Swachh Bharat Mission; but this is just not enough.[30] These households have access to electricity, but not enough resources to either buy cooling devices or pay hefty power bills. These factors make dwellers of informal settlements highly vulnerable to urban heat.

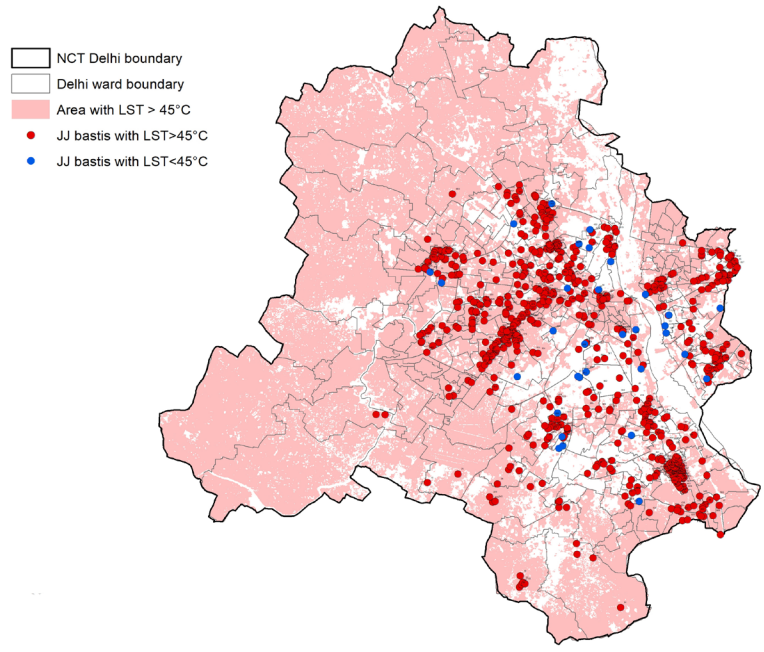
CSE's on-ground assessment

CSE mapped 675 jj *bastis* across Delhi using data from DUSIB.[31] These settlements comprise of approximately 3,06,521 households, holding an estimated 1.54 million people.

Ward-level distribution shows that each of Delhi's 181 wards has at least one jj *basti*. Some wards have more than 30, says DUSIB. Harkesh Nagar (39 *bastis*) and Tahkhand (35) have the highest numbers. These are followed by Kirti Nagar (16), Vivek Vihar (12), Ashok Vihar (12), Hari Nagar (12), NDMC Ward 9 (10), New Seema Puri (10), Sri Niwaspuri (10), and Mansarover Garden (10). Other wards with significant *basti* presence include Naraina and Inder Lok Colony (nine each); and Minto Road, Nizamuddin, Nanak Pura, Sangam Park, Nimri Colony, R K Puram, Majnu Ka Tila, Timar Pur, and Nangal Raya – each of these have seven to eight *bastis*.

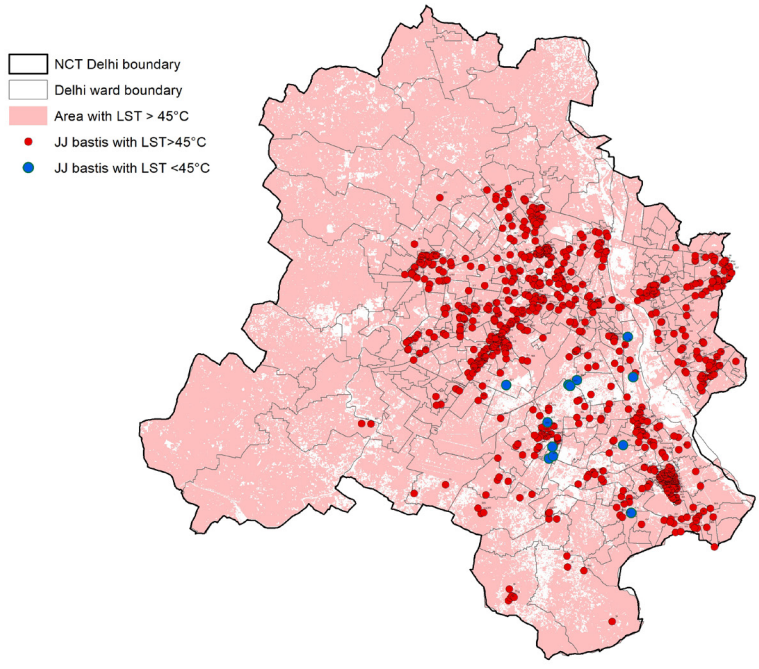
Of the total mapped *bastis*, 516 (~76 per cent) – with 2,63,031 households (nearly 1.32 million people) – are located in heat-stressed areas (*see Map 14: JJ bastis located in heat-stressed areas, 2015-24*). Further, 652 *bastis* (~97 per cent) – home to nearly 1.52 million residents – fall within areas where LST crossed 45°C at least once in the summer months (April-June) in the past decade (*see Map 15: JJ bastis located in areas where LST crossed 45°C at least once in summer months*).

Map 14: JJ bastis located in heat-stressed areas, 2015-24



Source: Created by CSE using data from DUSIB and USGS Earth Explorer (Landsat 8/9)

Map 15: JJ bastis located in areas where LST crossed 45°C at least once in summer months



Source: Created by CSE using data from DUSIB and USGS Earth Explorer (Landsat 8/9)

Resource-poor and vulnerable: The homeless

The homeless population in any city counts among the most exposed and under-served groups – Delhi is no exception. With access to practically nothing – including safe water, sanitation, electricity, shade and healthcare – these people are often forced to sleep in open, heat-retaining environments: pavements, foot overbridges, under flyovers, traffic medians, or vacant plots. In all these places, prolonged exposure to radiant heat easily becomes life-threatening. According to a report by the New Delhi-based Centre for Holistic Development, 192 homeless individuals died due to heat between June 11 and June 19, 2025 in Delhi.[32]

Delhi has at least 0.3 million (three lakh) homeless people, says a recent survey by the New Delhi-based non-governmental organisation, Housing and Land Rights Network (HLRN).[33] This is more than six times the number estimated under Census 2011. In response, DUSIB has constructed and operates 195 shelters, which includes 82 permanent structures, 103 porta cabins and 10 other shelters to cater to only about 19,000 persons.[34]

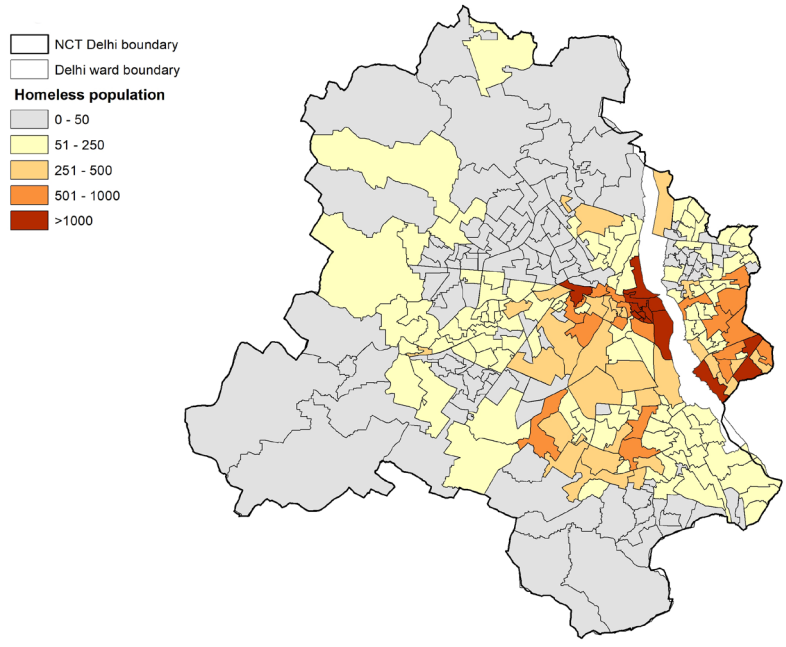
The 2021 Master Plan for Delhi proposes one shelter capable of hosting 100 persons for every one lakh (0.1 million) population. The survey reports that even these shelters are under-occupied due to poor thermal comfort, safety, hygiene and lack of water and sanitation.

Spatial distribution and CSE's assessment

According to a 2024 survey by HLRN, there is a high concentration of homeless people in Central Delhi, followed by East Delhi (*see Map 16: Ward-wise distribution of surveyed homeless population*). The wards in Central Delhi include Chandni Chowk, Ballimaran, Jama Masjid, Kucha Pandit, Idgah Road, Daryaganj, Minto Road, Bazar Sitaram, Pahar Ganj and Karol Bagh. East Delhi wards include Trilok Puri, Patparganj, New Ashok Nagar, Mayur Vihar Phase I and Phase II, Dallopura, Khichripur, Kalyan Puri, Kondli and Gharoli.

These wards largely hold labourers who work in the walled city during the day and sleep on the pavements at night. Public places like Kashmere Gate ISBT and the parks adjacent to the Yamuna also hold a lot of homeless persons. This is mainly because these areas are equipped with infrastructure such as foot overbridges and highways which provide shade and spots to squat on. The temples in the vicinity provide food and water. The wards in East Delhi have industrial labour as well who live on the streets.

Map 16: Ward-wise distribution of surveyed homeless population



Source: Created by CSE using data from HLRN and USGS Earth Explorer (Landsat 8/9)

Another noticeable cluster of homeless people is seen near the All India Institute of Medical Sciences (AIIMS). These people are mostly from poor and marginalised communities; they travel to Delhi for treatment of medical conditions at AIIMS, and are forced to wait for this treatment for days with no means of buying a temporary roof over their heads.

Physiological vulnerability to heat: Women, elderly and children

Women, elderly and children (under nine years of age) are groups that are sensitive to urban heat due to their physiology. Socio-economic conditions such as the nature of employment, income, access to water, sanitation and healthcare further compromise the vulnerability faced by these groups. For instance, an elderly woman working outdoors in a marginal job is among the most vulnerable. This reality needs to be considered while planning for heat resilience of these groups.

Women

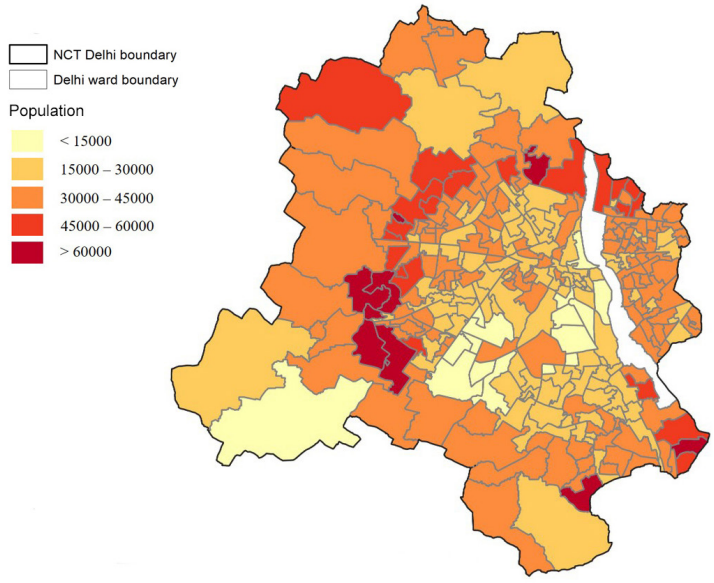
Women are more sensitive to heat than men. Their thermo-regulation is weaker (compared to men) due to lower sweat rates, delayed onset of sweating and lesser skin blood flow.[35] Hormonal fluctuations, particularly during menstruation or menopause, further alter thermoregulatory efficiency.[36] During pregnancy, women

face elevated risks of dehydration, heat exhaustion and pre-term labour when exposed to extreme heat.[37] Socio-economic constraints increase their vulnerability.

Women in Delhi are quite engaged in the informal sector, which involves livelihoods like domestic work, street vending, sanitation work, ragpicking, construction, home-based work, among others. These tasks involve outdoor exposure without access to much safeguards such as clean water, toilets or healthcare.[38] Within households, women are subjected to indoor heat from poorly ventilated kitchens, especially where traditional fuels are used.[39] Studies also indicate that cultural norms often limit women's mobility and decision-making during emergencies, delaying their response to heat-related illnesses.[40]

CSE extrapolated the population of women in Delhi using the Census 2011 data and projections for 2021 made in the Population Projection Report 2020 by the Union Ministry of Health and Family Welfare (*see Map 17: Ward-wise women's population in Delhi 2021 (projected)*).[41] Ward-level distribution for women in Delhi reveals that 18 wards – Matiala, Hastsal, Kunwar Singh Nagar, Mukund Pur, Jaitpur, Mohan Garden, Prem Nagar, Kakraula, Said-ul-Ajab, Madanpur Khadar, Pooth Kalan, Sonia Vihar, Bhalswa, Rohini, Budh Vihar, Kirari Suleman Nagar, Jharoda and Qamruddin Nagar – have female populations exceeding 50,000. The highest concentrations were found in Matiala (84,215) and Hastsal (83,057). Many of these wards fall within areas that face recurrent heat stress.

Map 17: Ward-wise women's population in Delhi 2021 (projected)



Source: CSE analysis based on data from Census 2011 and Ministry of Health and Family Welfare's Population Projection Report 2020

Children (zero-nine years)

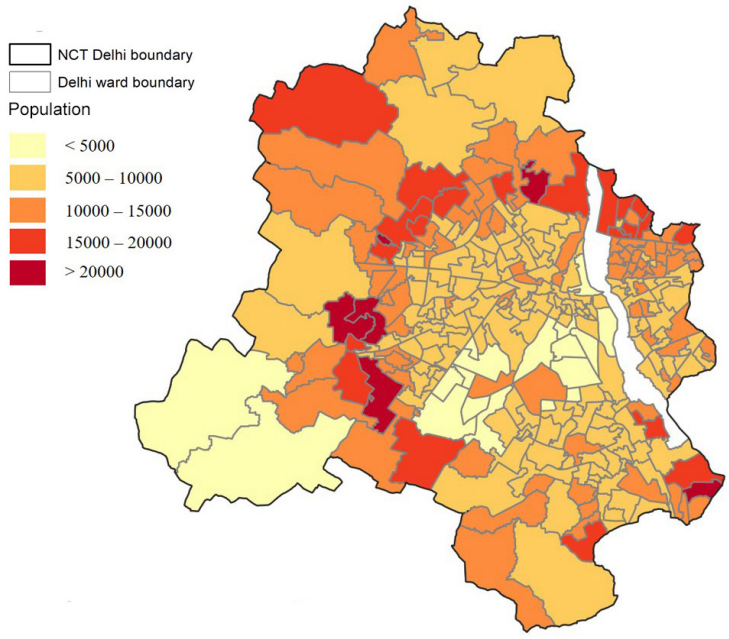
Apart from their physiology, children are vulnerable to heat due to behavioural characteristics. Children have a higher surface area-to-body mass ratio compared to adults, leading to greater heat absorption per unit of body mass.[42] Immature sweat glands and lower sweat rates[43] reduce their ability to cool down through evaporation. Their shorter height places them closer to hot ground surfaces, which intensifies exposure to radiant heat. Children's skin is also more sensitive to sun exposure, making them more susceptible to sunburn and related skin conditions.[44]

Higher levels of physical activity – particularly during school hours and outdoor play – contribute to increased metabolic heat production, while the thermoregulation capacity is underdeveloped. Extended periods in poorly ventilated classrooms or outdoor exposure during peak heat hours may lead to overheating, fatigue and reduced cognitive performance. Prolonged exposure to heat has been associated with concentration loss and learning disruption.

A changing climate is increasing children's exposure to heat – summers have become longer with extreme heat episodes occurring as late as July and August. But in Delhi, most schools have their summer vacation from mid-May to the end of June, says the Directorate of Education. This misalignment exposes children to heat stress in their daily school routine. As schools cannot close due to heat beyond an extent, there is a need to find ways to make the environment around children heat-resilient and to enhance their coping capacity.

CSE distributed the projected (2021) population of children in Delhi spatially at the ward level and found that six wards – Matiala, Hastsal, Kunwar Singh Nagar, Mukund Pur, Jaitpur and Prem Nagar – had more than 20,000 children each in the zero-nine age group (*see Map 18: Ward-wise population of zero-nine year age group – 2021 (projected)*). This was followed by 22 wards that had between 15,000 and 20,000 children each. These wards are largely peripheral wards where self-construction takes dominance. The levels of service in most of these wards in terms of safe water, toilets, shaded and green spaces, healthcare facilities – among other things – is weaker than in the wards that are centrally located.

Map 18: Ward-wise population of zero-nine year age group – 2021 (projected)



Source: CSE analysis based on data from Census 2011 and Ministry of Health and Family Welfare's Population Projection Report 2020

INTERVENTIONS IN SCHOOLS: THE SOLAR OPTION

Rooftop space in schools can be an important resource for heat management and climate mitigation. As schools are one of the more widely present infrastructures in the neighbourhoods of Delhi, their rooftop space has strong potential for solar energy generation and cool roof programmes. Delhi could harness this potential to build heat resilience not only for children, but also for the community.

Solar panels on roofs help in managing heat by a combination of actions. They reflect a significant portion of the heat back and prevent the roof from absorbing solar radiation and transferring it to the indoors of a building. While providing a 'cool roof' effect, solar rooftops in schools can build a clean energy source in addition to reducing the cooling energy demand.

CSE mapped 1,066 schools in Delhi – about 18.8 per cent of the total 5,669 registered schools that have over 4.47 million enrolments as of 2025, according to the Union Ministry of Education.[45] Of the mapped schools, nearly 80 per cent lie in heat-stressed locations (*see Map 19: The mapped schools (~18.80 per cent of the total number of schools) in Delhi*). These mapped schools span a total area of 941.38 hectare (ha)[1], having around 829.48 ha of estimated rooftop space. Considering that nearly 50 per cent of this area can be used to generate solar energy, these school rooftops can support 13.73 megawatt peak (MWp) of solar photovoltaic capacity.

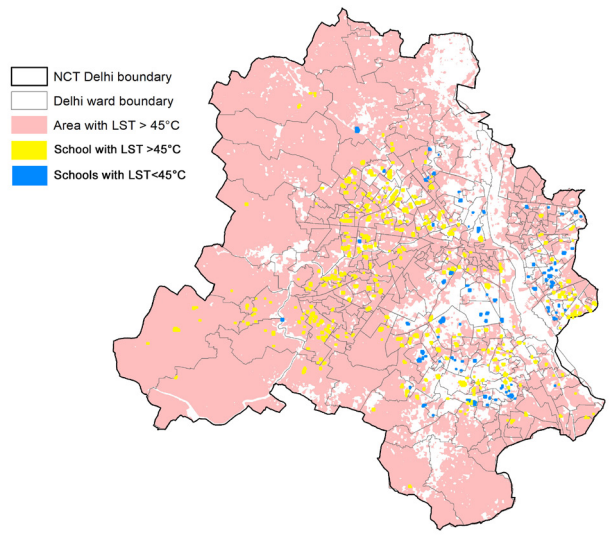
Extrapolation to all registered schools in Delhi results in nearly 73 MWp of solar energy potential. This could generate nearly 79.4 million kilowatt-hours of electricity annually, accounting for seasonal variations in solar output. At current grid emission factors provided by the Central Electricity Authority, this translates to an annual reduction of approximately 57,754 tonne of CO_2 equivalent emissions.[46] This highlights the scale at which rooftop

1 According to Master Plan for Delhi 2021

solar can mitigate heat through a passive cooling strategy and contribute to Delhi's clean energy transition.

Such interventions in schools play a wider role in building community resilience. Schools can create a layer of safeguards for a city with cool roof and solar rooftop solutions. They can also function as community shelters during heat emergencies, and as demonstration centres for shaping heat resilience for other institutions and the community.

Map 19: The mapped schools (~18.80 per cent of the total number of schools) in Delhi



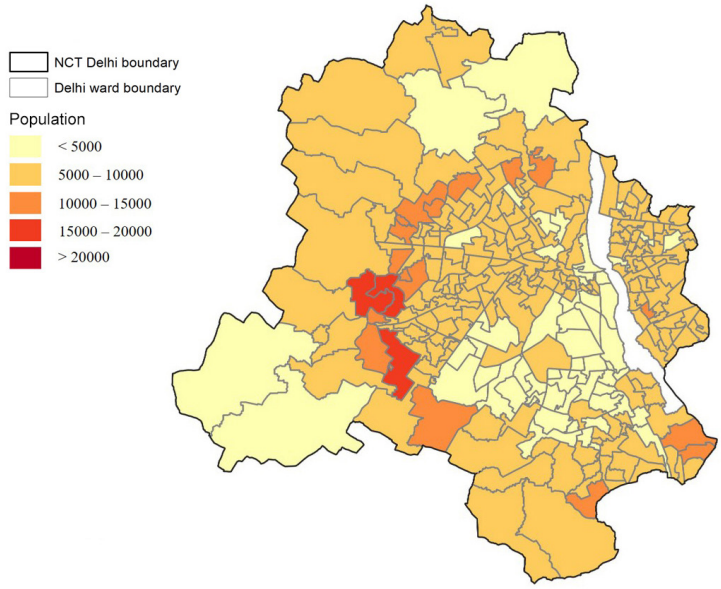
Source: Created by CSE using data from the Union Ministry of Education and USGS Earth Explorer (Landsat 8/9)

The elderly

The population aged 60 and above is vulnerable to heat due to natural physiological decline which includes reduced skin blood flow, diminished sweat gland activity, and a slower onset and rate of sweating – making it harder to dissipate heat effectively during high temperatures.[47] Any pre-existing health conditions or illnesses such as cardiovascular, pulmonary, renal or metabolic issues adds to this. Medications for these conditions further disrupt the body's fluid balance and natural heat response.[48] Many elderly people also experience diminished thirst perception and reduced mobility, which delay their response to heat stress.[49]

CSE distributed the projected (2021) population of the elderly in wards and found that three wards have more than 15,000 elderly persons each (*see Map 20: Ward-wise population for 60+ age group – 2021 (projected)*). These include Hastsal,

Map 20: Ward-wise population for 60+ age group – 2021 (projected)



Source: CSE analysis based on data from Census 2011 and Ministry of Health and Family Welfare's Population Projection Report 2020

Kunwar Singh Nagar and Matiala. These are followed by 16 wards that have elderly people numbering between 10,000 to 15,000 each. Most of these wards are peripheral. While the elderly need to be advised to stay indoors during extreme heat, they need cooling infrastructure support at their homes or old-age facilities to compensate for their physiological disadvantage.

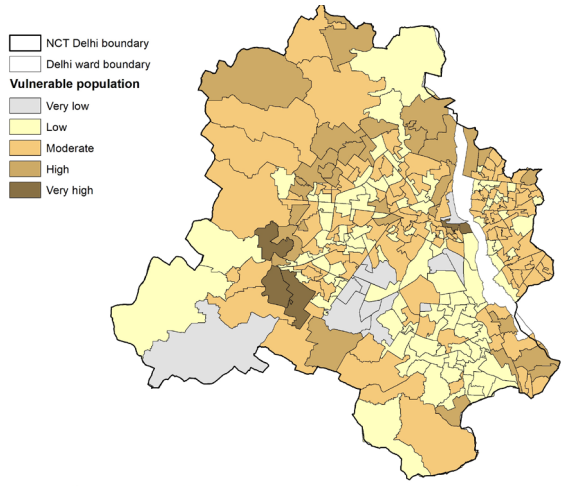
Cumulative vulnerability

Ward-wise distribution of vulnerable groups has shown that there are certain wards that house high populations of one or more of these groups. A cumulative overlay informs which of the wards in Delhi must be prioritised for action due to high concentration of vulnerable populations as well as high exposure to heat.

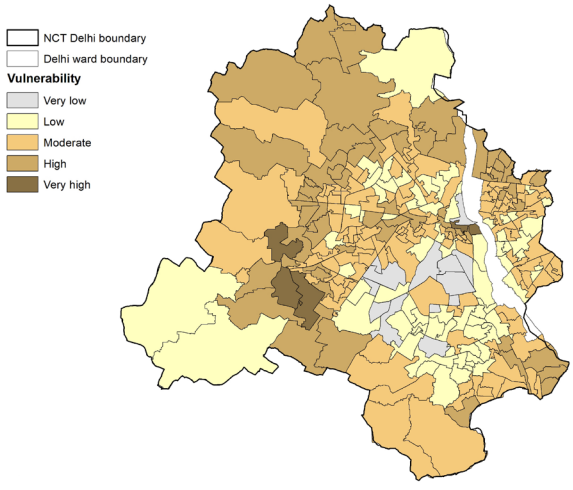
Thirty-five wards in the city have 'Very High' and 'High' concentrations of vulnerable populations (*see Map 21: Ward-wise distribution of vulnerable populations*). Chandni Chowk, Hastsal, Kakraula and Matiala are the four wards with 'Very High' vulnerable populations; Mukundpur, Narela, Bawana, Rohini, Burari, Ballimaran, Mohan Garden, Okhla and Malka Ganj, among others, feature on the 'High' list.

Overlaying these wards with heat-stressed zones reveals that nearly one-third of Delhi's wards have Very High to High vulnerability (*see Map 22: Cumulative*

Map 21: Ward-wise distribution of vulnerable populations



Map 22: Cumulative vulnerability in wards



Source: Created by CSE using data from the Union Ministry of Education and USGS Earth Explorer (Landsat 8/9)

vulnerability in wards). While most of the wards with Very High vulnerability are those located at the city's periphery (such as Matiala, Kakraula, Hastsal, Narela, Bawana and Mukundpur), Chandni Chowk is the only ward from the old city to fall in this category.

Wards in the High vulnerability category are also mostly peripheral wards that are witnessing large-scale self-construction and development of unauthorised colonies. Some of these wards are Bhalswa, Burari, Shiv Vihar, Badarpur, Nangloi, Najafgarh and Chhattarpur, among others. Many Central Delhi wards also fall in this category.

This analysis emphasises two things: one, the uneven distribution of heat across the city and two, the uneven impact of heat on people. Taking these into consideration, it serves to pinpoint the areas that need urgent action; these are the areas that suffer from a lack of safeguards and hold a high concentration of vulnerable people. The strategy for heat resilience in Delhi needs to address both these aspects in emergency response as well as for longer term mitigation. This should include actions such as incorporating passive cooling techniques in buildings, increasing shading (trees and artificial structures), providing access to early warning system, healthcare, awareness on self-diagnosis and first aid, and installing cooling infrastructure like access to safe water, toilets, shade and cooling devices.

6

A ROADMAP FOR BUILDING RESILIENCE

Tackling Delhi's heat challenge requires a shift from passive reaction to active planning that integrates governance changes, scientific heat metrics (Heat Index), targeted cooling infrastructure, and diversified financing strategies. CSE proposes a two-pronged strategy: one, measures to be taken all the year round for the entire population and two, measures focused on vulnerable groups.

Some of the proposed year-round measures include recognising and notifying heat as a disaster; instituting a dedicated body to plan, implement and coordinate heat resilience actions; adopting better heat measurement indicators; disseminating heat information; implementing city-wide cooling solutions like nature-based actions and thermally efficient roofs in a planned manner; initiating climate-appropriate building and infrastructure design; reinforcing specialised healthcare focused on heat; and sourcing funds.

Measures focused on vulnerable populations can include ensuring registration and classification of informal workers; providing access to thermally comfortable housing; developing heat standards and SOPs for different occupations; institutionalising cool clothing and food; and providing fiscal and medical support.

The strategies to reduce heat vulnerability of identified groups and build city-wide heat resilience in Delhi can be divided into two categories:

1. Measures to be taken all the year round for the entire population
2. Measures focused on vulnerable groups

Strategic plan I: Year-round activities for all

Recognise heat as a disaster: Most states in India conduct disaster response and relief work under the Disaster Management Act, 2005. The Act does not list 'extreme heat' as a disaster: as a result, the states had also been ignoring it. But with growing concern around extreme heat conditions, states have now started officially recognising heat as a 'notified disaster' – many, including Tamil Nadu, Maharashtra, Odisha, Haryana, Uttar Pradesh and Kerala, have done so. But Delhi has not done this yet. In order to use the State Disaster Response Fund for relief work – including healthcare support, ex-gratia for heat-related casualties, planning and implementing mitigation measures, among other welfare support – Delhi will have to notify heat as a disaster.

Circulate heat alerts based on better indicators: The IMD issues heat alerts based on maximum air temperature readings.[50] Research has shown that increasing humidity is becoming a bigger concern and contributing to heat stress. Indicators like wet bulb temperature or heat index are closer to felt heat and humidity. For instance, relative humidity in Delhi ranges from 40 per cent to 100 per cent through April to August. At an average relative humidity level of 65 per cent, temperatures above 37°C feel like 40-51°C outdoors and fall in 'extreme caution' category (*see Figure 2: Heat index in °C converted from NOAA's National Weather Service*). Heat index has been widely adopted across the world as a primary indicator for heat-related guidance and heat management in cities. While IMD had launched an 'Experimental Heat Index' in 2023, India needs to link that with heat warnings based on native normals. India needs to adopt such indicators and classify heat warnings based on native temperature normals.

Develop a dynamic heat stress dashboard: Currently, heat mapping is based on land surface temperatures (LSTs). There is a need to assess and disseminate information on heat stress levels based on heat index: this will show the real 'feel' and the real-time threat. Delhi needs a public dashboard that allows users to learn whether they are located in heat-stressed areas or how much area of their ward is under heat stress (*see Figure 3: A heat dashboard for Delhi*). Wards must also show in this dashboard the concentrations of population from vulnerable groups, so that prompt action could be taken by the concerned authorities in case of heat

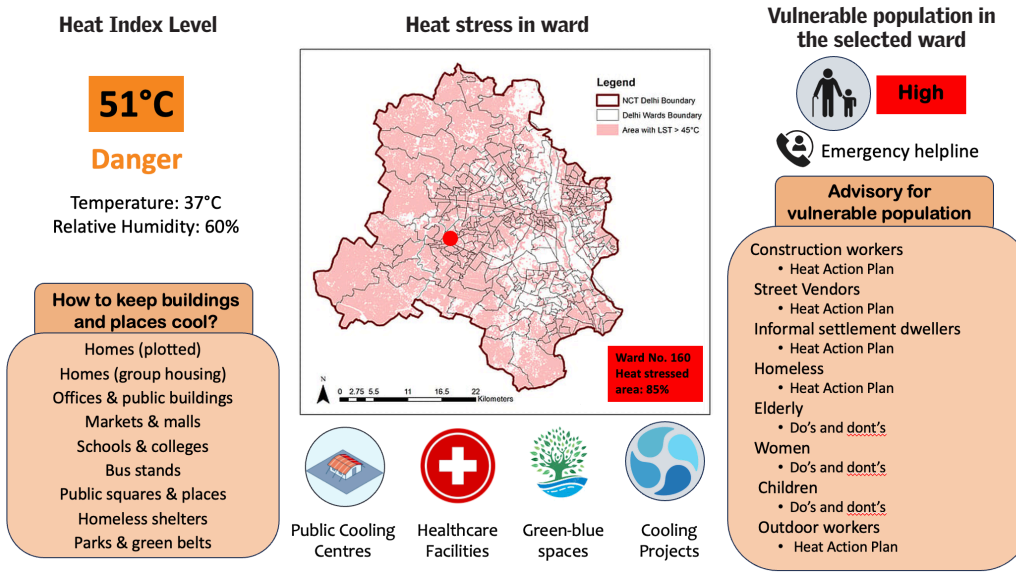
Figure 2: Heat index in °C converted from NOAA's National Weather Service

Caution | Extreme Caution | Danger | Extreme Danger

Relative Humidity %	Temperature °C																
	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
40	27	28	29	30	31	32	34	35	37	39	41	43	46	48	51	54	57
45	27	28	29	30	32	33	35	37	39	41	43	46	49	51	54	57	
50	27	28	30	31	33	35	36	38	41	43	46	49	52	55	58		
55	28	29	30	32	34	36	38	40	43	46	48	52	54	58			
60	28	29	31	33	35	37	40	42	45	48	51	55	59				
65	28	30	32	34	36	39	41	44	48	50	55	59					
70	29	31	33	35	38	40	43	47	50	55	58						
75	29	31	34	36	39	42	46	49	53	58							
80	30	32	35	38	41	44	48	52	57								
85	30	33	36	39	43	47	51	55									
90	31	34	37	41	45	49	54										
95	31	35	38	42	47	51	57										
100	32	36	40	44	49	56											

Source: NOAA's National Weather Service

Figure 3: A heat dashboard for Delhi



emergencies. This will allow clarity in heat action, especially for employers and regulating bodies as well as enforcement agencies when needed.

The dashboard must guide users with heat alerts, warnings, permissible activities and special advisories for vulnerable groups as per the heat action plan. It should also hold knowledge resources to combat heat, such as guidelines to retrofit houses, workspaces and public places with cooling solutions involving thermally-efficient roofs, shading devices, enhanced ventilation and measures for microclimate enhancement. Passive design and material choice guidelines can guide people as well as authorities to build thermally comfortable houses, offices and workspaces.

Assess thermal comfort conditions and needs in public buildings: Delhi has a lot of public and semi-public buildings including offices, schools, colleges, district shopping complexes and local markets. There is a need to develop cooling audit guidelines to assess the thermal performance of these buildings and work out possible solutions to keep them cool without turning to ACs as a first-stop solution. Factors like the condition of the roof, shading devices on windows, ventilation inside the building etc can be checked for interventions. Retrofitting with cool roof, shades and awnings, vertical fins and the use of roof or gable openings for ventilation are easy-to-implement solutions that can reduce heat gain by up to 6°C. Further, a solar rooftop can function dually – as a cool roof and a clean energy source. This needs to be mandated in public buildings.

Plan for and develop city-wide cooling solutions: Delhi needs to plan for and develop infrastructure for heat resilience proactively and not as a response to increasing episodes of heat waves. The CSE assessment has revealed that the city can be classified into some key categories based on when and why the areas get heat-stressed. The first category includes areas that heat up in early summer (April) – mainly the industrial areas, large portions of the walled city and villages that are transforming into self-constructed and informal settlements. These are the high priority areas. The second category has areas that heat up in peak summer (May and June) and includes residential colonies (planned and unauthorised), markets, commercial and transit hubs, institutional complexes, etc. These areas need deeper assessments and context-sensitive solutions keeping in mind the vulnerable population.

Then come the built-up areas that do not get heat and show resilience. This third category includes the planned residential colonies that can still improve the quality of greens, deploy cool roofs, retrofits, renewable energy and low-carbon cooling to stengthen resilience. The fourth category involves the green-blue infrastructure

that is falling under heat stress: this consists mainly of the grassed areas, dried-up ridges and the river's flood plain. These areas need interventions like improving the quality of greens with native species, thick canopy trees among others. The fifth category is the new development taking place on agricultural land and the redevelopment projects that have started reshaping the morphology of core areas.

The assessment of Delhi's exposure to heat stress in the past decade has provided a cue for prioritisation and intensification of cooling efforts based on which morphologies are performing well for thermal comfort and which are not (*see Table 1: Guidance map for different morphologies and developments in Delhi*). Addressing these morphologies with appropriate solutions can not only reinforce public health safeguards in the city, but also mitigate heat to a great extent while placing it on a decarbonisation trajectory.

Table 1: Guidance map for different morphologies and developments in Delhi

Areas/strategy	Nature-based solutions	Thermally-efficient roofs	Climate-appropriate planning and design		Non-refrigerant-based cooling systems	Efficient refrigerant-based cooling systems
			Indoor	Outdoor		
High priority areas		✓	✓	✓	✓	✓
Areas with potential for resilience	✓	✓	✓	✓	✓	
Resilient areas		✓	✓	✓		
Heat-stressed green blue infrastructure	✓					
New development	✓	✓	✓	✓	✓	✓
Redevelopment	✓	✓	✓	✓	✓	✓

- ***Nature-based solutions:*** According to a study in IWA, green and blue elements like vertical greens, green roofs, fountains/sprinklers, parks, lakes, etc can regulate the microclimate and bring down local temperatures by 5°C and up to a distance of 250 m.[51] These features have been formalised by the addendums to the Urban and Regional Development Plan Formulation and Implementation Guidelines, 2014 and the Model Building Bye Laws, 2016 released by the MoHUA: these recommend integrating urban forestry, increasing tree cover and restoring and conserving waterbodies with Master Plans as the primary safeguards for a city from heat.

  The draft Master Plan of Delhi-2041 also has a section on enhancing green-blue infrastructure with a three-fold goal of conserving existing greenery and waterbodies, creating new green-blue infrastructure, and adding green and blue elements in the built fabric. Indicators like the Green-Blue Factor provide

for the requirement of green-blue elements in new developments. This needs to be implemented stringently in all new constructions. Delhi also needs to guide its inhabitants on how to improve the quality of greens by focusing on thick canopy native varieties of trees over shrubs and grass.

- ***Thermally-efficient roofs:*** Also known as cool roofs, these are a low-hanging fruit that can reduce both indoor and outdoor temperatures. Roofs that use either insulation, reflection, vegetation or a combination of these techniques can reduce indoor temperatures by up to 5°C and ambient temperatures in a range of 0.3°C to 3°C. Surface temperature reduction is much higher. Delhi is dominated by a low-rise typology of buildings, which makes cool roofs more implementable with clear roof rights, compared to cities with high-rise buildings. Therefore, if the Master Plan of Delhi-2041 calls for mandatory cool roofs, it can make a huge difference. These must be implemented with priority in industrial areas, office complexes, markets and commercial hubs as they heat up faster than the rest of the city. Programmes that deploy cool roofs in informal settlements, schools, old age homes, homeless shelters and dwellings of construction workers can reduce the heat burden of the vulnerable groups.

- ***Climate-appropriate planning and design:*** Passive techniques such as orienting layouts to allow less exposure to the sun; building geometry and material choice that reduce heat gain; and use of different types of shading devices on doors and windows to cut direct solar ingress can increase annual thermal comfort hours by 22 per cent, according to a CSE study.[52] Placement of blocks in a way that harnesses local wind flows can improve indoor as well outdoor thermal comfort substantially. The MoHUA has prepared the PRITHVI guidelines for single-family homes and multi-family apartments to guide thermal comfort in residential buildings.[53,54] These need to be mandated by integrating them with building bye-laws. Water elements like bio-swales, rain gardens and fountains can also reduce ambient temperatures. While a majority of these techniques are feasible for new developments, certain aspects can be integrated with existing buildings. These include installation of shading devices and retrofits to improve roof condition and ventilation. Public places can be retrofitted with water elements and shading devices as well to improve the microclimate and outdoor thermal comfort conditions.

- ***Non-refrigerant-based cooling systems:*** Non-refrigerant-based or structure cooling has the potential to reduce indoor temperatures by 10-12°C. These technologies can also prevent waste heat discharge from buildings to outdoors, unlike conventional ACs. The India Cooling Action Plan, 2019 supports adoption of such technologies to meet the target to reduce cooling

energy demand by 2037-38. A CSE study titled *Cooling Web* documents a few such systems that have a lower energy and carbon footprint compared to conventional cooling systems.[55] New developments and redevelopments, especially institutional buildings, need to explore these technologies. High pressurized misting system and evaporative cooling can also be deployed for public cooling at such as bus stops, transit hubs, street vending zones, etc.

- ***Efficient refrigerant-based cooling systems:*** Air conditioning is emerging as a necessity to combat growing heat. This is supported by increasing affordability of and access to ACs. According to the Bureau of Energy Efficiency (BEE), district cooling systems are more efficient than conventional room ACs in terms of electricity consumption and use of refrigerants. Such systems provide more opportunities to prevent release of the waste heat into the ambient environment – and instead, reutilise it. For instance, there are systems that take the waste heat from ACs into water to meet hot water requirements of the inhabitants in a building. As Delhi is going through major redevelopment in several parts of the city, it needs to explore delivery of 'Cooling as a Service' (CaaS) and reduce the contribution of ACs in heating up the city. The city must recognise such systems in the Master Plan of Delhi, 2041 and incentivise them in all new development.

Install public cooling infrastructure: As Delhi faces hotter days every summer, it needs to prepare public infrastructure and amenities to provide people some relief from the heat. These include drinking water stations, toilets, shaded rest or recreational places (with trees or artificial canopies), and evaporative cooling/misting systems in addition to the green-blue infrastructure of the city. Another layer of public cooling infrastructure that Delhi needs to prepare is the one required for emergency periods. This involves public buildings such as community centres, libraries, swimming pools, primary schools, primary health centres, *barat ghar*s (marriage halls), anganwadi centres, transit hubs, senior citizen's recreation centres, temple complexes etc. As new infrastructure would incur high costs, repurposing existing public infrastructure after necessary retrofits for cooling is more feasible. The purpose of these buildings would be to shelter people, especially outdoor workers and homeless, during a heat emergency. Mapping of these elements and their dissemination in the public domain is also important.

Set up a dedicated institution to plan for and manage heat the year-round: Current heat action in Delhi has a disaster response approach. It needs to be changed into an active heat management approach. This will require a robust framework to prepare the city to withstand rising heat, and at the same time, mitigate emissions. A dedicated institution to develop and implement this framework is crucial to set things in motion.

MoHUA has launched an initiative titled Building Heat Resilient Cities: A Strategic Pilot for Urban India' to plan a heat resilience framework for selected cities based on assessments and implement a context-specific pilot to demonstrate cooling action with urban local bodies (ULB). Further, the MoHUA's CITIIS 2.0 (City Investments to Innovate, Integrate and Sustain 2.0') initiative is preparing a three-tier framework for climate action. National, state and city level structures include the National Climate Data Observatory, the State Climate Centre for Cities and the State Climate Data Platform, and the Department of Climate Action under ULBs. This means that a majority of the strategic and action planning and implementation is going to take place at the city level and anchored by ULBs. This is consistent with MoHUA's Climate Smart Cities Assessment Framework 3.0, which expects cities to prepare their climate action plans and designate an implementing body – a ULB-level climate coordination cell. Delhi has a state Climate Change Cell established in 2018 under the Department of Environment – but the city needs to do more.

Delhi needs a planning, implementation and coordination body at the ULB level for an ear-to-the-ground approach. The Delhi State Climate Action Plan proposes strategies like a dedicated Environment Service Zone in each area, green buildings, water conservation and waste management etc under the urban planning sector. While these strategies are in the right direction, they are also quite open-ended and do not have any performance indicators for monitoring and evaluation. The focus on heat management is limited to increasing green spaces in the city. Delhi needs a comprehensive assessment of its vulnerabilities and actions to build heat resilience in a short and long term manner. A designated city-level body can enable this.

Plan for financing heat resilience action: Implementing actions for heat resilience requires fiscal support. The city government's finance department has budgeted Rs 14,228 crore to implement the key strategies under each sector of the Delhi Action Plan on Climate Change. Beyond this, the department will seek support from the national government and several external multilateral and bilateral funding sources. There are many avenues that can bring in the requisite funding for necessary short-term and long-term measures. Broad categories are ongoing programmes and schemes, global funds and arrangements, and innovative instruments.

Ongoing initiatives which could be sources for funds include the National Adaptation Fund for Climate Change, PMAY 2.0, Technology Innovation Grant, Ayushman Bharat Health Insurance Scheme, AMRUT, Smart Cities Mission, Swachh Bharat Mission, DUSIB funds for slum rehabilitation, and any other state welfare fund that can be used directly.

Global funds include the Green Climate Fund (GCF), Adaptation Fund and other bilateral and multilateral arrangements which could fiscally support heat mitigation in Delhi. A city can directly access these funds through a procedure. For instance, GCF involves approximately a year-long procedure set in motion by a National Designated Authority for Green Climate Fund which prepares or collects a funding proposal made by an accredited entity, gets it vetted by a technical advisory panel, and approved by the GCF Board (*see Figure 4: Framework for disbursement of GCF fund to cities for heat mitigation*). Similarly, NABARD is the national implementing entity which approves projects for accessing the National Adaptation Fund for Climate Change. This national fund has been created for the Adaptation Fund under Kyoto Protocol (*see Figure 5: Framework for accessing the National Adaptation Fund for Climate Change*).

Figure 4: Framework for disbursement of GCF fund to cities for heat mitigation

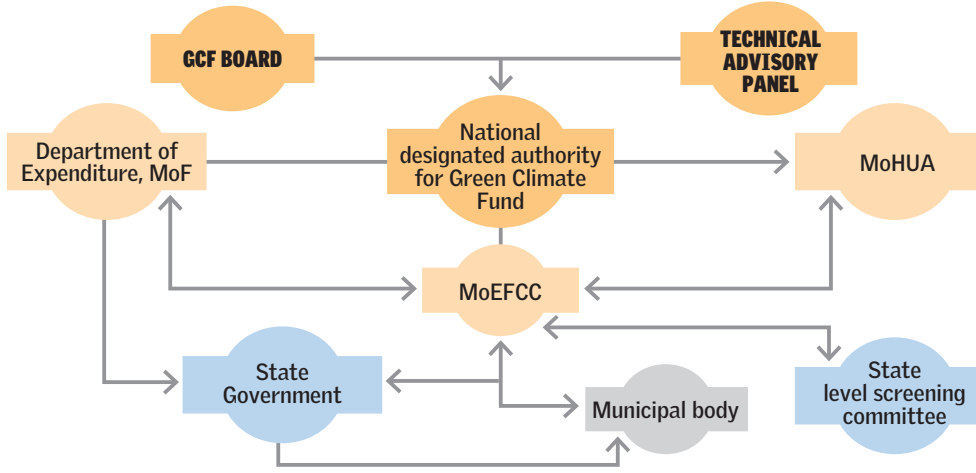
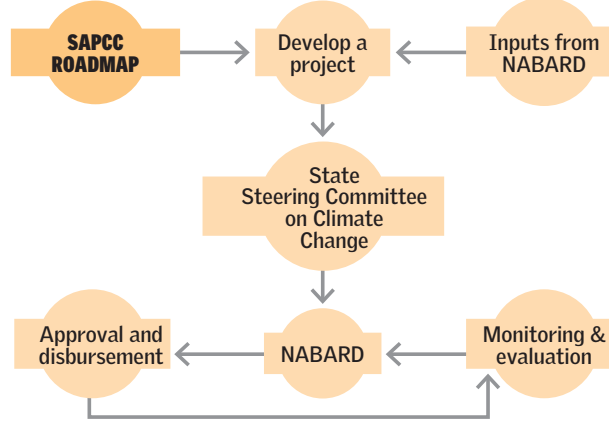


Figure 5: Framework for accessing the National Adaptation Fund for Climate Change



Other instruments like green bonds or climate bonds specifically earmarked for climate and heat-related projects can be explored by the Municipal Corporation of Delhi (MCD). For this, the ULB must set a defined criteria that must be relevant and outcome-oriented. Several cities, according to a study by South Pole and CapaCITIES 2022, a network of governing institutions for climate-neutral and smart cities, have raised Green Municipal Bonds – these include Ghaziabad, Ahmedabad, Surat, Visakhapatnam, Amravati, Indore, Bhopal, Pune, Hyderabad, Lucknow and Vadodara.[56] Currently, green bonds encompass renewable energy, energy efficiency, clean transportation, green buildings, natural resources and land use, water and waste management, and pollution prevention and control. While these sectors overlap with the nature of action required for heat mitigation, the qualifying criteria can be set to meet the direct requirements to combat heat. The newly announced Urban Challenge Fund supports such instruments while involving private sector investment. Innovative instruments like parametric insurance rolled out by the Ahmedabad Municipal Corporation can be explored keeping vulnerable groups in mind as well.

Reinforce healthcare: Heat wave episodes in recent years have revealed inadequate medical staff at hospitals in Delhi to handle heat emergency cases. Hospitals, nursing homes and other healthcare facilities need to prepare with additional staff and resources in anticipation of an influx of heat-related cases. Further, hospitals also need to ensure expert staff to provide specialised treatment and care. The Ram Manohar Lohia (RML) Hospital and the Safdarjung Hospital in Delhi have such resources – these comprise equipment such as ice baths and dedicated wards for heat-related cases. The RML Hospital has also set up a dedicated helpline for these cases. This needs to be expanded to other hospitals as well.

Prepare a heat emergency response template for all employers and citizens: All industries, sectors and institutions need to prepare emergency response plans – similar to fire emergency plans. Currently, institutions do not have any resources or guidance on what do when the heat index hits danger levels. They rely on government orders as and when they are notified, mostly in an emergency period. Institutions need to prepare for and build heat resilience autonomously throughout the year and act swiftly during an emergency. There is a need for a model heat emergency plan that could guide all institutions to prepare their own emergency responses depending on the kind of industry, workspace or residential area. This could include strategies to reduce exposure like staggering of work timings, moving work indoors or under shade (in case of outdoor activities), and improving improving long term adaptive capacity by facilitating mandatory and adequate cooling resources like water stations, toilets, shaded or ventilated resting areas, healthcare, and ORS, ice packs, etc for emergencies.

Build awareness and capacity to manage heat: All industries, sectors and institutions including market associations, resident's welfare associations, schools, colleges and workplaces need to be sensitised on the problem of rising heat and what they can do to reduce its impacts. Firstly, assessing the level of heat by using metrics like 'feels-like temperature', understanding early warnings released by the IMD or DDMA, and knowing when to avoid outdoors is critical. Secondly, deliberate action that mitigates heat has to emerge from the ground – such as adopting passive measures in buildings, solar rooftops, and not only increasing greenery but also selecting trees over grass and the ones that provide shade over the ones that do not. The built environment community is the focal point for creating awareness on these aspects. Lastly, people should be made aware of the day-to-day measures to shield themselves from heat, such as through clothing and food. They should also know how to diagnose heat-related illnesses like heat rashes, heat stress, heat cramps, heat exhaustion and heat stroke and the next course of action and treatment. This is vital for outdoor workers and needs to be a priority for their employers and associated institutions. This should be done with support from medical professionals.

Strategic plan II: Measures focused on vulnerable groups

Ensure proper registration of informal workers: Delhi has a large number of people engaged in the informal sector. Independent research based on the Primary Labour Force Survey of 2018-19 place this as high as 80 per cent. This population comprises construction workers, street vendors, domestic workers, gig workers (delivery persons), casual labourers etc. This huge demographic group remains unable to receive benefits related to social security, insurance, healthcare or emergency response – primarily because there are no clear records of their existence.

In 2021, following the exodus of migrant workers during the COVID-19 pandemic, the Union Ministry of Labour and Employment had launched the e-Shram portal for registering this workforce. Delhi indicates 35.8 lakh (3.58 million) registrations, of which 4.6 lakh (0.46 million) are construction workers.[57] But independent research suggests that this enumeration has not translated into any benefits for the individual workers.[58] These registrations need to be continued and linked with early warnings and welfare programmes, especially in response to a heat-related emergency.

Initiate steps for classification of informal workers: Associations regulating informal workers or employers need to classify their workforce based on the nature of work or any physiological vulnerability. For instance, construction activities can

be classified as high, medium or low risk depending on how physically demanding they are. Working at elevated and confined spaces, manual lifting and transporting of materials, operating vibrating power tools, any work with repetitive motion that could lead to strain or injury and any work with heavy equipment qualify for a high risk category. These activities increase physical and mental drain due to high heat and could compromise safety of self and others. High risk workers could include women (especially pregnant women), workers above 50 years of age with pre-existing medical conditions, those with no previous exposure to hot workplaces and those with a history of heat-related ailments, among others.

Provide access to thermally comfortable housing: A majority of the identified vulnerable groups do not live in thermally comfortable housing. The Pradhan Mantri Awas Yojana-Urban (PMAY) 2.0, which was launched in 2015, set out a renewed target in 2024 – of constructing one crore (10 million) affordable houses. Delhi has constructed only 30,159 dwellings as of August 2025, a miniscule figure compared to the housing demand of the city.[59] The demand survey for PMAY 2.0 has begun and Delhi has a great opportunity to construct thermally comfortable affordable housing for vulnerable groups using the thermal comfort guidelines (PRITHVI for single-family and multi-family dwellings) developed under the Global Housing Technology Challenge.[60] These guidelines need to be linked with the Technology Innovation Grant that provides fiscal support for use of non-conventional construction technology. PMAY 2.0 also has a very relevant component of affordable rental housing near workplaces, primarily for migrant workers and the urban poor, including construction workers. Delhi needs to utilise these instruments.

Develop heat standards for different occupations and prepare standard operating procedures (SOPs): The Occupational Safety, Health and Working Conditions Code, 2020 provides for declaration of standards for occupational safety and health for workplaces including factories, mines, shipping docks, buildings and other construction work, among others. These standards need to recognise exposure to ambient heat as a health and safety concern. Accordingly, every sector/industry needs to develop and notify standard operating procedures (SOPs) for heat management. These SOPs must include Do's and Don'ts for heat wave periods for different kinds of workplaces. Further, legislations like the Factories Act of 1948, Street Vendors (Protection of Livelihood and Regulation of Street Vending) Act of 2014, and the Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act of 1996 need to recognise exposure to ambient heat as an occupational hazard and threat to public health.

Institutionalise cool clothing and food: Outdoor workers must wear clothing made of thin cotton that are loose-fitting and light in weight and colour. Construction workers could be provided with hard hats to protect the head, neck and face from direct sunlight. Wearing of personal protective equipment needs to be managed contextually – it may need to be taken off at times for the thermal comfort of the wearer. Advanced clothing such as cooling vests (PVC vests with fan) could be explored.

Facilities that provide food to vulnerable groups such as canteens at construction sites, boarding schools and schools that provide mid-day meals, old age homes, industries with meal service and canteens for workers need to be trained for preparing meals that support both hydration and nutritional needs. Adding nutrients such as potassium and magnesium can increase one's resilience towards heat. Meals should include electrolyte-based drinks. Schemes and programmes that support nutrition in mass/community kitchens such as the PM POSHAN scheme for school children must acknowledge this. Different industries and sectors need to incorporate these aspects in their SOPs.

Provide dedicated fiscal support: Heat has a direct impact on the well-being and livelihoods of vulnerable groups. They require safety nets and may need to take measures to adapt to the extreme temperatures, such as clean and cold drinking water, cooling devices, medical access and reflective paints for roofs. These measures incur financial costs that the vulnerable are not able to bear. Therefore, cities need to create these safety nets.

The Delhi Building and Other Construction Workers Welfare Board levies a cess on every construction activity at the rate of one to two per cent. This fund is earmarked to be used for the welfare of registered labour – in 2024, the Delhi government announced an *ex-gratia* amount of Rs 8,000 for construction workers who were affected by the ban on construction activities during the air pollution emergency. This fund needs to be made available for heat-related emergencies as well.

The SEWA and Mahila Housing Trust in Ahmedabad have deployed a parametric insurance for women artisans. This insurance is linked to the ambient temperature, which triggers automatic payouts of up to Rs 2,000 per year on breaching a certain threshold. Following its success, the Ahmedabad Municipal Corporation has internalised this instrument in its city heat action plan. More such financing instruments need to be explored and dedicated to the vulnerable. Several schemes

such as PM SVANidhi, Deendayal Antyodaya Yojana-National Urban Livelihoods Mission (DAY-NULM) and the Ayushman Bharat scheme also need to be leveraged for this.

Provide access to medical screening: Closely monitor physiological conditions of construction workers, women, children and elderly in workspace, including their heat exposure history, pulse rate, body temperature (oral or tympanic), body weight, blood pressure, respiratory rate and alertness during high heat periods. Organise medical camps near homeless shelters as well.

7

AN ACTION PLAN

How can Delhi respond to conditions of extreme heat in a way that will help all and the most vulnerable on priority?

CSE proposes an action plan for Delhi in which different heat index levels can be linked to risk levels, depending on their public health and livelihood impacts: these have been clubbed under four categories. Each category provides a specific approach for various groups to respond to the heat threat (*see Table 2: Responses to different heat index levels*).

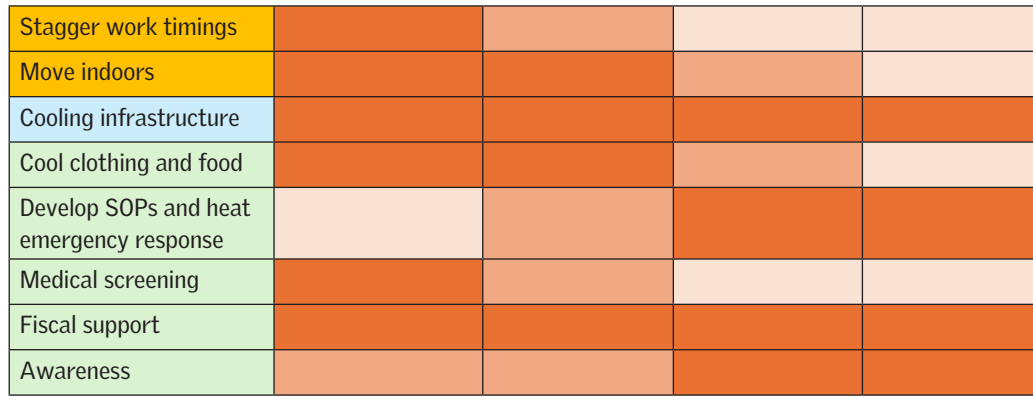
For vulnerable groups, three kinds of strategies are recommended: reduce exposure, mitigate and increase adaptive capacity (*see Table 3: Priority index for strategies during different heat index levels*). Reducing workloads and the duration of work (with more breaks), staggering work timings, and moving indoors are the key recommended actions to **reduce exposure** of vulnerable populations. **Mitigation** measures involve planning, development and maintenance of cooling infrastructure. **Increasing adaptive capacity** includes actions such as encouraging cool clothing and food, developing SOPs and emergency response, medical screening, fiscal support and increasing awareness.

Table 2: Responses to different heat index levels

Heat index (feels-like temperature) category	Risk level	Response
Caution (27-32°C) and below	Low	Year-round measures: Plan for emergency preparedness and long-term heat resilience and implement with priority in heat-stressed wards with high vulnerable populations.
Extreme caution (33-39°C)	Medium	Avoid non-essential exposure, increase awareness and enforce precautionary measures. Year-round measures: Plan for emergency preparedness and long-term heat resilience and implement with priority in heat-stressed wards with high vulnerable populations.
Danger (40-48°C)	High	Reduce exposure across the city with priority to the relatively more vulnerable groups such as pregnant women, elderly, young children (10 years and below), and those with co-morbidities and history of heat-related illnesses. Mass dissemination of heat alerts and precautions to be taken.
Extreme danger (49°C and above)	Emergency	Emergency response: No outdoor activities to be done city-wide during peak heat hours (12-4 PM). Minimise exposure for the vulnerable throughout the day. Mobilise public cooling infrastructure. Emergency services and healthcare to remain vigilant. Mass dissemination of heat alerts and precautions to be taken.

Table 3: Priority index for strategies during different heat index levels

Strategy/ heat index levels	Emergency	Danger	Extreme caution	Caution and below
Reduce workload				
Reduce duration of work (more breaks)				



Nature of strategies

Reduce exposure | Mitigate | Increase adaptive capacity

Priority levels for strategies

High | Medium | Low

Table 4: Measures for vulnerable groups during 'Extreme Danger' heat index levels

Response approach: Emergency

Strategy	Actions	Institutions
Reduce workload	**Construction workers** • No high risk worker to be engaged city-wide • No activities to be done during peak heat period (12-4 PM) city-wide • Acclimatise by exposing workers who have not worked in hot environments before progressively to reduce thermal load on the body. US OSHA guidelines suggest 50 per cent exposure on day one, 60 on day two, 80 on day three, and 100 per cent on day four	Labour department, GNCTD, developers' associations
	Women • No pregnant women to be engaged outdoors by employers. Employers to offer 'work from home' wherever possible • Reduce the shift for sanitation workers and other employees who work outdoors – from eight hours to six	Department of Women and Child Development, GNCTD, MCD, DDA, NDMC, DCB
	Children No outdoor sports or other outdoor activity to take place in schools for older children (11 years and above)	Directorate of Education, GNCTD
	Elderly No elderly person to be engaged by employers	LAbour DEpartment, GNCTD, Department of Health and Family Welfare, GNCTD
Reduce duration of work (more breaks)	**Construction workers** • Provide cooling breaks several times throughout the day. More frequent breaks for medium intensity work and medium risk workers are recommended – for instance, a 15-minute break every two hours	Labour department, GNCTD, developers' associations

Strategy	Actions	Institutions
	Women • Provide cooling breaks to women engaged in industrial work once every two hours for 10-15 minutes. Explore reducing shift duration by one-two hours • Provide frequent cooling breaks to domestic workers	Department of Women and Child Development, GNCTD, MCD, RWAs, Labour department GNCTD
	Children • Ensure frequent breaks for drinking water and toilet for older children (11 years and above). Directorate of Education, GNCTD has recently announced a 'water bell' that reminds children to drink water during studies twice a day	Directorate of Education, GNCTD
Stagger timings	**Construction workers** • While a regular shift starts at 9-10 AM and ends at 5-6 PM, reschedule work to start at 7-8 AM or end at 7-8 PM • Shift activities in large-scale projects to night time wherever possible	Labour department, GNCTD, developers' associations
	Women • Shift work timings for domestic workers and industrial workers towards early morning wherever possible	Department of Women and Child Development, GNCTD, MCD, Labour Department, GNCTD, RWAs, Labour department GNCTD
Move indoors	**Construction workers** • Engage workers in indoor activities or move them to shaded areas wherever possible	Labour department GNCTD, developers' associations
	Street vendors • All mobile vendors to move to local shaded vending zones/spots during peak heat hours (12-4 PM)	Town Vending Committees, MCD, DDA, DCB, NDMC, RWAs
	Homeless Move all homeless to temporary or permanent shelters	DUSIB, MCD
	Women • All women to remain indoors as much as possible, especially those with co-morbidities, or those who are pregnant, and those with a history of heat-related illnesses	Department of Women and Child Development, GNCTD, MCD, NDMC, DCB, DDA, RWAs, Labour department GNCTD
	Children • Schools to move to online mode for young children (up to 10 years of age) • Primary schools to convert into public cooling centres to provide access to water, toilets and resting places to outdoor workers and temporary shelter to homeless	Directorate of Education, GNCTD, MCD, DUSIB
	Elderly All senior citizens to remain indoors as much as possible	Department of Health and Family Welfare, GNCTD
Cooling infrastructure	• Declare identified and equipped public buildings as public cooling centres and open them for outdoor workers • Allow night shelters in public cooling centres wherever feasible (such as community centres, barat ghars, libraries, etc • Ensure that cooling devices like fans and desert coolers in canteens, resting places, homeless shelters and worker dormitories are in working condition	MCD, DDA, DUSIB, LAbour DEpartment, GNCTD

Strategy	Actions	Institutions
Cool clothing and food	**Construction workers** • Provide hard hats to protect the head, neck and face from direct sunlight • Explore advanced clothing such as cooling vest (PVC vest with fan) • Wearing of personal protective equipment needs to be managed contextually. It may help in preventing dehydration in certain cases and may need to be taken off for ventilation at other times	Labour Department, GNCTD, developers' associations
	• Employers to deploy cool clothing and gear	
	• Employers and institutions to ensure that institutional kitchens deploy menu with cooling food and drinks	
Medical support	• Establish free medical camps (spot and mobile) near workplaces of vulnerable populations, informal settlements and shelters for homeless in wards with high concentration of these groups • These camps must be equipped with monitoring of physiological conditions of workers including pulse rate, body temperature (oral or tympanic or core), body weight, blood pressure, respiratory rate and alertness etc • These camps must have ice packs, ice baths and other resources needed to rehydrate and bring core body temperature down rapidly	Department of Health and Family Welfare, GNCTD, MCD, DDA, NDMC, DCB
Fiscal support	• Disburse fiscal support against lost livelihoods to pregnant women, elderly, high-risk construction workers, and other sensitive population groups that work outdoors like industrial workers, delivery boys, etc	Labour Department, GNCTD, MCD, DDA, NDMC, DCB
Awareness	• Conduct mock drills and create awareness on heat waves, self-diagnosis for heat-related illnesses and next steps • Provide guidance on easy-to-implement measures for increasing thermal performance of homes	Department of Health and Family Welfare, GNCTD, MCD, DDA

Table 5: Measures for vulnerable groups during 'Danger' heat index levels

Response approach: Reduce exposure

Strategy	Actions	Institutions
Reduce workload	**Construction workers** • No high-risk worker to be engaged in 'Very High' and 'High' heat stress wards • No high- and medium-risk activities to be done across the city during peak heat period (12-4 PM) • Acclimatise by exposing workers who have not worked in hot environments before progressively to reduce thermal load on the body – US OSHA guidelines suggest 50 per cent exposure on day one, 60 on day two, 80 on day three, and 100 per cent on day four	Labour department, GNCTD, developers' associations
	Women • No pregnant women to be engaged in 'Very High' and 'High' heat stress wards. Employers to allow 'work from home' wherever possible • Reduce the shift for sanitation workers and other employees who work outdoors from eight hours to seven	Department of Women and Child Development, GNCTD, MCD, NDMC, DCB, DDA, RWAs, Labour department GNCTD

Strategy	Actions	Institutions
	Children No outdoor sports or other outdoor activities to take place in schools	Directorate of Education, GNCTD
	Elderly No elderly person to be engaged in 'Very High' and 'High' heat stress wards	Labour Department, GNCTD, Department of Health and Family Welfare, GNCTD
Reduce duration of work (more breaks)	**Construction workers** • Provide cooling breaks several times throughout the day – for instance, a 15-20 minute break every three hours	Labour Department, GNCTD, developers' associations
	Women • Provide cooling breaks to women engaged in industrial or outdoor work once every two-2.5 hours for 10-15 minutes each. Explore reducing shift duration by one hour • Provide frequent cooling breaks to domestic workers	Department of Women and Child Development, GNCTD, MCD, NDMC, DCB, DDA, RWAs, Labour department GNCTD
	Children • Ensure frequent breaks for drinking water and toilet	Directorate of Education, GNCTD
Stagger timings	**Construction workers** • While a regular shift starts at 9-10 AM and ends at 5-6 PM, reschedule work to start at 7-8 AM or end at 7-8 PM • Shift activities in large-scale projects to night time wherever possible	Labour Department, GNCTD, DEvelopers' associations
	Women • Shift work timings for domestic workers and industrial workers towards early morning wherever possible	Department of Women and Child Development, GNCTD, RWAs, Labour department GNCTD
Move indoors	**Construction workers** • Engage workers in indoor activities or move them to shaded areas wherever possible	Labour Department, GNCTD, developers' associations
	Street vendors • All mobile vendors to move to local shaded vending zones/spots during peak heat hours (12-4 PM)	Town Vending Committees, MCD, DDA, DCB, NDMC, RWAs
	Homeless • Move to temporary or permanent shelters	DUSIB, MCD, DDA, NDMC, DCB
	Women All women located in 'Very High' and 'High' heat stress wards to remain indoors as much as possible, especially those with co-morbidities, those who are pregnant, and those with a history of heat-related illnesses	Department of Women and Child Development, GNCTD, RWAs, Labour department GNCTD, MCD, DDA, NDMC, DCB
	Children • Schools to explore moving to online mode for young children (up to 10 years of age)	Directorate of Education, GNCTD
	Elderly All senior citizens located in 'Very High' and 'High' heat stress wards to remain indoors as much as possible, especially those with co-morbidities and with a history of heat-related illnesses	Department of Health and Family Welfare, GNCTD, RWAs
Cooling infrastructure	• Declare identified and equipped public buildings as public cooling centres and open them for outdoor workers • Allow night shelter in public cooling centres wherever feasible (such as community centres, barat ghars, libraries, etc) • Ensure that cooling devices like fans and desert coolers in canteens, resting places, homeless shelters and worker dormitories are in working condition	MCD, DDA, NDMC, DCB, DUSIB, Directorate of Education, GNCTD

Strategy	Actions	Institutions
Cool clothing and food	**Construction workers** • Provide hard hats to protect the head, neck and face from direct sunlight • Explore advanced clothing such as cooling vest (PVC vest with fan) • Wearing of personal protective equipment needs to be managed contextually. It may help in preventing dehydration in certain cases and may need to be taken off for ventilation at other times	LAbour DEpartment, GNCTD, developers' associations
	• Employers to encourage use of cool clothing and gear	
	• Employers and institutions to ensure that institutional kitchens deploy menu with cooling food and drinks	
Medical screening	• Establish free medical camps (spot and mobile) near workplaces of vulnerable populations and shelters for homeless in wards with high concentrations of these groups • These camps must be equipped with monitoring of physiological conditions of workers including pulse rate, body temperature (oral or tympanic or core), body weight, blood pressure, respiratory rate and alertness • These camps should have ice packs, ice baths and other resources needed to rehydrate and bring body temperature down rapidly	Department of Health and Family Welfare, GNCTD, Labour Department, GNCTD
Fiscal support	• Disburse fiscal support against lost livelihoods to pregnant women, elderly, high-risk construction workers, and other sensitive population groups that work outdoors like industrial workers, delivery boys, etc	Labour Department, GNCTD, MCD, DDA, NDMC, DCB
Awareness	• Conduct mock drills and create awareness on heat waves, self-diagnosis for heat-related illnesses and next steps	Labour Department, GNCTD, Department of Health and Family Welfare, MCD, NDMC, DCB

Table 6: Measures for vulnerable groups during 'Extreme Caution' heat index level

Response approach: Avoid inessential exposure, increase awareness and implement mitigation and resilience strategies

Strategy	Actions	Institutions
Reduce duration of work (more breaks)	**Construction workers** • Provide cooling breaks several times throughout the day in projects located in 'Very High' and 'High' heat stress wards – for instance, a 15-20 minute break every three hours	Labour department, GNCTD, developers' associations
	Women Provide cooling breaks to women engaged in industrial and outdoor work twice during the shift for 10-15 minutes each. More breaks to pregnant and elderly women	Department of Women and Child Development, GNCTD, RWAs, Labour department GNCTD, MCD, DDA, NDMC, DCB
	Children Introduce frequent breaks for young children (up to 10 years of age) for drinking water and toilet	Directorate of Education, GNCTD
	Elderly Provide cooling breaks to elderly engaged in industrial and outdoor work twice during the shift for 10-15 minutes	Labour Department, GNCTD, Department of Health and Family Welfare, GNCTD

Strategy	Actions	Institutions
Move indoors	**Construction workers** • Engage workers in indoor activities or move them to shaded areas wherever possible, especially in 'Very High' and 'High' heat stress wards	Labour department, GNCTD, developers' associations
	Street vendors • All mobile vendors to move to local shaded vending zones/spots during peak heat hours (12-4 PM) in 'Very High' and 'High' heat stress wards	Town VEnding Committees, MCD, DDA, DCB, NDMC, RWAs
	Homeless • Move all homeless to temporary or permanent shelters in 'Very High' and 'High' heat stress wards	DUSIB, MCD, DDA, NDMC, DCB
	Women All women to avoid inessential outdoor activities, especially pregnant women and elderly women	Department of Women and Child Development, GNCTD, RWAs, Labour department GNCTD, MCD, DDA, NDMC, DCB
	Children • Schools located in 'Very High' and 'High' heat stress wards to explore moving to online mode for young children (up to 10 years of age) • Avoid inessential outdoor activities for young children (up to 10 years of age)	Directorate of Education, GNCTD
	Elderly All elderly to avoid inessential outdoor activities	Department of Health and Family Welfare, GNCTD, RWAs
Cooling infrastructure	**Construction workers** • Upgrade canteens and worker dormitories as per the retrofitting plan • Ensure cooling devices like fans and desert coolers in canteens, resting places and worker dormitories. Make sure that they are working • Ensure shaded or ventilated break areas • Ensure safe water and sanitation on site • Ensure ORS, ice packs and hydration kits on site	Labour department, GNCTD, developers' associations
	Street vendors • Use collapsible or fixed tensile reflective structures for shading in vending zones in the absence of adequate trees of shade • Weekly markets to use collapsible reflective shading structures • Explore fans, misting or evaporative cooling devices in the vending zones and weekly markets wherever feasible • Ensure safe water and sanitation facilities at weekly markets, street markets and vending zones • Explore and promote cool carts that use passive and active cooling solutions for thermal comfort and prevent spoilage (see Box: Cool carts)	Town vending committees, MCD, DDA, DCB, NDMC, RWAs
	Informal settlement dwellers • Retrofit roofs in informal settlements with insulating materials, shading devices and reflective paints on priority • Apply light-coloured reflective paint/finish on facades and roofs • Use insulated material like PUF insulated panels, or spray foam, bamboo mats, fibreglass mats, etc inside metal roofs	DUSIB, MCD, DDA, NDMC, DCB
	Homeless • Implement construction of new permanent shelters as per the requirement and design guidelines • Implement design/retrofitting of temporary shelters as per the plan and guidelines • Check conditions of cooling devices like fans and desert coolers for peak summer months (May-August) and ensure that they are working • Check and ensure availability of safe water and sanitation on or near the site (not more than 50 m away)	DUSIB, MCD, DDA, NDMC, DCB

Strategy	Actions	Institutions
	Women • Ensure there are safe drinking water points, toilets and shaded resting areas in each ward for sanitation workers and outdoor workers	Department of Women and Child Development, GNCTD, RWAs, Labour department GNCTD, MCD, DDA, NDMC, DCB
	Children • Implement retrofitting plan in schools based on the survey of the state of cooling infrastructure • Ensure that there is one safe and accessible drinking water point per 50 students in the school in working condition • Ensure that there is one toilet for every 40 boys and one for every 25 girls in schools in clean and working condition	Directorate of Education, GNCTD
	Elderly • Implement retrofitting plan based on the survey of cooling infrastructure • Ensure safe water and sanitation at senior citizen recreation centres, libraries and old age homes • Ensure senior citizen recreation centres, libraries, old age homes etc have energy-efficient fans and desert coolers • Keep ORS, ice packs and hydration kits at senior citizen recreation centres, libraries and old age homes	Department of Social Welfare, GNCTD, MCD, DDA, DCB, NDMC
Cool clothing and food	• Employers to deploy use of cool clothing and gear • Employers and institutions to ensure that institutional kitchens deploy menu with cooling food and drinks	Labour Department, GNCTD, Department of Health and Family WElfare, GNCTD
Develop SOPs and heat emergency response	All employers and institutions to prepare SOPs for heat management in summer months (April to August). These SOPs must include: • Understanding heat alerts and warnings • Guidance on cool clothing such as that made of thin cotton, loose fitting, light in weight and colour • Guidance for institutional kitchens to include hydrating or electrolyte-based food and drinks such as coconut water, buttermilk, sattu, aam panna, wood apple (bael) juice, cucumbers, onions, bottle gourd, watermelons, melons, mint, fennel, coriander, etc • Guidance on self-diagnosis for heat-related illnesses and necessary action to minimise damage • Classification of activities based on the strain they cause on the body in high heat and humidity. This includes activities that are physically demanding and involve operation of heavy machinery and equipment in construction • Classification of workers based on physiological response to heat – such as women, elderly, those with co-morbidities, and history of heat-related illnesses – so that these people could be safeguarded first in the event of high heat • Guidance on relaxations in work including reduction in workload, increase in breaks, staggering of work shift timings, work from home etc	LAbour DEpartment, GNCTD, Department of Health and Family WElfare, GNCTD
Fiscal support	• Regulating bodies, employers to access and maintain funds to extend support during heat emergencies such as livelihood loss, healthcare, access to cooling solutions etc. These funds could also be used for developing cooling infrastructure ahead of extreme heat periods • Disburse fiscal support against lost livelihoods in heat-stressed wards to pregnant women, elderly, high risk construction workers, and other sensitive population groups that work outdoors like industrial workers, delivery boys, etc	Department of Urban Development, GNCTD, Labour Department, GNCTD, MCD, DDA, NDMC, DCB
Awareness	• Conduct mock drills and create awareness on heat waves, self-diagnosis for heat-related illnesses and next steps • Concerned government bodies to provide guidance on easy-to-implement measures for increasing thermal performance of houses	Labour Department, GNCTD, Department of Health and Family Welfare, Department of Urban Development, MCD, NDMC, DCB

COOL CARTS

Irish firm Trane Technologies has created a cart prototype for street vendors that tackles two significant issues: extreme heat exposure and food waste.

Prominent features of the design include:

- Shade and insulation: The cart is equipped with a canopy made of a thin reflective film that blocks direct sunlight, reducing the temperature of stored vegetables by 6-8°C – without any energy input. The design also considers the angle of incidence to minimise solar penetration.
- Ventilation design: Cross-ventilation and breathable materials are integrated to limit heat build-up and improve airflow within the cart.
- Heat-reflective materials: The use of insulating and high-albedo materials helps maintain lower internal temperatures, improving thermal comfort for both the vendor and the produce.
- Lightweight and ergonomic: Designed for ease of movement, the cart ensures vendors can relocate with minimal effort, supporting both flexibility and comfort during peak summer hours.

Cart design seeking thermal comfort of vendor
Photo credit: https://www.thermalcontrolmagazine.com/cooling/trane-technologies-empowers-indian-street-vendors-with-cooling-carts/

Air-cooled-based vegetable vending cart
Photo credit: https://iitr.ac.in/Departments/Hydro%20and%20Renewable%20Energy%20Department/Activities/Air-Cooled%20Based%20Vegetable%20Vending%20Cart.html

Air-cooled-based vegetable vending cart, developed by the Department of Hydro and Renewable Energy at IIT Roorkee in Uttarakhand is another example. This mobile preservation unit addresses a key challenge faced by street vendors – produce spoilage due to high daytime temperatures. Traditional open carts often lead to faster degradation of fruits and vegetables, with every 10°C rise in temperature accelerating spoilage by two–three times. In peak summers, freshness lasts only one-two days, resulting in wastage or forced low-price sales.

The air-cooled cart offers a compact solution by maintaining an internal temperature drop of 10-15°C and 85 per cent humidity, extending the freshness of produce to three-four days. This significantly reduces spoilage, improves hygiene and enhances income security for vendors by reducing losses.

- Target users: Fruit, vegetable and fast-food vendors
- Approximate cost: Rs 40,000 per unit
- Impact: Minimises perishability, supports efficient vending, and enables sustained operations during extreme heat.

Table 7: Measures for vulnerable groups during 'Caution' heat index level

Response approach: Increase awareness and implement mitigation and resilience strategies

Strategy	Actions	Institutions
Cooling infrastructure	**Construction workers** • All sites with over 500-sq m plot area to have temperature monitoring instruments installed and provide access to information on heat index levels • Survey the condition of canteens, worker dormitories and rest of the site to ensure adequate arrangements to combat heat. Prepare a retrofitting plan accordingly • Check if canteens and worker dormitories can be: - placed close to or under trees - insulated with materials like PUF insulated panels, or spray foam, bamboo mats, fibreglass mats, etc inside metal/fibre roofs - applied with light-coloured reflective paint/finish on facades and roofs; avoid glass facades as they trap heat - cross-ventilated with windows/doors on opposite sides, roof of gable opening, and direct night airflow through steep roofs and low openings - fixed with overhangs on south and west facades to cut heat gain - shaded using sun-blinds, canvas or shade nets in windows and roofs • Check if there are adequate cooling devices like fans and desert coolers in canteens, resting places and worker dormitories and that they are working • If there are shaded or ventilated break areas at the site • If there is adequate safe water and sanitation on site • If there is emergency relief kit including ORS, ice packs and hydration kits on site	Labour department, GNCTD, developers' associations
	Street vendors • Conduct surveys to identify vending zones in each ward or neighbourhood • Plan for vending zones near local parks, waterbodies or spots/alleys with canopy trees or near fountains • Plan for and install collapsible or fixed tensile reflective structures for shading in vending zones in absence of adequate trees of shade. • Provide permeable pavement at weekly markets, street markets and vending zones • Plan for safe water and sanitation facilities at weekly markets, street markets and vending zones • Explore and promote cool carts that use passive and active cooling solutions for thermal comfort and prevent spoilage	Town vending committees, MCD, DDA, DCB, NDMC, RWAs'
	Informal settlement dwellers • Conduct surveys on informal settlements in Delhi, their population, location, condition of the dwelling including wall and roof material, and cooling devices available • Plan for retrofitting roofs in these settlements with insulating materials, shading devices and reflective paints on priority • Affordable housing projects to adopt passive design principles for composite climate as recommended in PRITHVI guidelines	DUSIB, MCD, DDA, NDMC, DCB, DEpartment of Urban DEvelopment, GNCTD, CSOs, NGOs

Strategy	Actions	Institutions
	Homeless • Map locations and capacity of homeless shelters in the city • Survey the conditions of these shelters including their wall and roof material, window numbers and their placement, and numbers of fans and coolers • New permanent shelters to adopt passive design principles for composite climate as recommended in MoHUA's PRITHVI guidelines for single- or multi-family homes which focuses on: - Orientation of the unit to respond to the sun path and wind direction - Window design covering their placement, type, numbers and shading devices to be installed - Wall to be made using alternative construction techniques such as brick jali, cavity walls, etc - Materials in wall and roof to use local sustainable materials like mud, bamboo, etc or contemporary materials like AAC blocks, fly ash-based blocks or hollow blocks with light-coloured finish - Roofs to use one of these features – shade, insulate and reflect • Design/retrofit temporary shelters with following: - Place new structures close to or under trees wherever possible - Use insulated material like PUF insulated panels, or spray foam, bamboo mats, fibreglass mats, etc inside metal roofs - Apply light-coloured reflective paint/finish on facades and roofs, avoid glass facades as they trap heat - Ensure cross ventilation with windows/doors on opposite sides, roof of gable opening, and direct night airflow through steep roofs and low openings - Use overhangs on south and west facades to cut heat gain - Shade windows and roofs using sun-blinds, canvas or shade nets • Install cooling devices like fans and desert coolers for peak summer months (May-August) and ensure that they are working • Provide safe water and sanitation on or near site (not more than 50 m away)	DUSIB, MCD, DDA, NDMC, DCB, CSOs, NGOs
	Women • Plan and provide safe drinking water points, toilets and shaded resting areas in each ward for sanitation workers and outdoor workers • Improve the quality of green spaces in each ward by planting trees with thick foliage • Shade paved areas through trees or artificial shading devices wherever possible	Department of Women and Child Development, GNCTD, RWAs, Labour department GNCTD, MCD, DDA, NDMC, DCB
	Children • Evaluate thermal comfort conditions in schools covering roof condition, shading needs and ventilation as well as assess the state of cooling infrastructure covering water coolers, fans, toilets, emergency relief resources like ORS, ice packs, etc • Create a retrofitting plan for schools with cooling solutions like: - Apply light-coloured reflective paint/finish on facades and roofs, avoid glass facades as they trap heat	Directorate of Education, GNCTD

Strategy	Actions	Institutions
	- Use overhangs on south and west facades to cut heat gain - Shade windows and roofs using sun-blinds, canvas or shade nets - Greening solutions like vertical greens outside windows can work as shading devices that cut direct heat ingress - Shade any open paved area or convert them into permeable pavements - Shade any open walkways, corridors, assembly areas with artificial canopies, trees, etc - Integrate and increase vegetation by adopting green roofs or vertical greens • Plan and provide one safe and accessible drinking water point per 50 students in the school • Plan and provide one toilet for every 40 boys and one for every 25 girls in schools according to the Swachh Bharat Swachh Vidyalaya (SBSV) scheme • Mandate schools to install solar rooftop systems • Improve the quality of green spaces near schools by planting trees with thick foliage	
	Elderly • Survey the state of cooling infrastructure in senior citizen recreation centres, libraries, old age homes etc • Evaluate thermal comfort conditions including condition of roof, walls and shading devices • Create a retrofitting plan to improve condition of roof, walls and installing shading devices. This includes equipping senior citizen recreation centres, libraries, old age homes with: • light-coloured reflective paint/finish on facades and roofs – avoid glass facades as they trap heat • overhangs on south and west facades to cut heat gain • shading of windows and roofs using sun-blinds, canvas or shade nets • cross-ventilation with windows/doors on opposite sides, roof of gable opening, and direct night airflow through steep roofs and low openings • Equip senior citizen recreation centres, libraries and old age homes with energy-efficient fans and desert coolers • Provide safe water and sanitation at senior citizen recreation centres, libraries and old age homes • Keep ORS, ice packs and hydration kits at senior citizen recreation centres, libraries and old age homes • Install solar rooftop at senior citizen recreation centres, libraries and old age homes. • Improve the quality of green spaces near senior citizen recreation centres, libraries and old age homes by planting trees with thick foliage	Department of Social Welfare, GNCTD, MCD, DDA, DCB, NDMC, CSOs, NGOs

Strategy	Actions	Institutions
Develop SOPs and heat emergency response	All employers and institutions to prepare SOPs for heat management in summer months (April to August). These SOPs must include: • Understanding heat alerts and warnings • Guidance on cool clothing such as those made of thin cotton, loose fitting, light in weight and colour • Guidance for institutional kitchens to include hydrating or electrolyte-based food and drinks such as coconut water, buttermilk, *sattu, aam panna*, wood apple (*bael*) juice, cucumbers, onions, bottle gourd, watermelons, melons, mint, fennel, coriander, etc • Guidance on self-diagnosis for heat-related illnesses and necessary action to minimise damage • Classification of activities based on the strain they cause on the body in high heat and humidity. This includes activities that are physically demanding and involve operation of heavy machinery and equipment in construction • Classification of workers based on physiological response to heat such as women, elderly, those with co-morbidities, and history of heat-related illnesses so that these people could be safeguarded first in the event of high heat • Guidance on relaxations in work including reduction in workload, increase in breaks, staggering of work shift timings, work from home etc	LAbour DEpartment, GNCTD, Department of Health and Family WElfare, GNCTD
Fiscal support	• Regulating bodies and employers to access and maintain funds to extend support during heat emergencies such as livelihood loss, healthcare, access to cooling solutions among others. These funds could also be used for developing cooling infrastructure ahead of extreme heat periods	Department of Urban Development, GNCTD, Labour Department, GNCTD, MCD, DDA, NDMC, DCB
Awareness	• Concerned government body to increase awareness on rising heat, do's and don't's and measures to reduce the negative impact on health • Employers to train workers on the SOPs and heat emergency response • Employers to train workers and conduct mock drills on diagnosing symptoms of heat-related illnesses and next steps • Government bodies to provide guidance on easy-to-implement measures for increasing thermal performance of houses	LAbour DEpartment, GNCTD, Department of Health and Family WElfare, GNCTD, DDA, MCD

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Over 70 per cent of Delhi's area is persistently heat-stressed, a condition that has been worsened by a shrinking of the city's green-blue cover. Current actions to contain the crisis are proving to be insufficient because of a lack of a targeted resilience strategy for highly vulnerable groups such as construction workers, street vendors, informal settlement dwellers, children etc.

As the city comes face to face with another searing summer, we bring you a workable dual-strategy roadmap through this exhaustive analysis. On one hand, Delhi should begin implementing a series of year-round, city-wide actions such as mandating thermally efficient roofs and utilising better heat indicators. On the other, it should enforce focused interventions for exposed populations including mandatory cooling breaks, staggered work timings and dedicated fiscal support during heat emergencies.

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