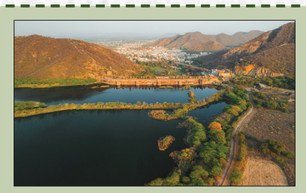
URBAN COOLING FRAMEWORK FOR JAIPUR



Green and Blue Infrastructure Intensification Zone

Jaipur's northern and eastern landscape is blessed with with an ample amount of natural resources. The Development Plan 2025 earmarks this zone as the Ecological zone and Green Zone comprising Reserve Forest, Protected Forest and Aravalli Hills respectively with a total area of 93 sq km. The framework pushes to conserve this natural heritage and further intensifying it with encroachment control, afforestation drives, promoting native species and soil and water conservation practices.

Low cost passive cooling solutions for vulnerable groups

Adaptive Resilience Zone

This zone largely addresses the municipal area and aims to regulate indoor and outdoor temperatures to ensure cooling equity. Practices that demonstrate good adaptive performance need to be understood and pushed for scaled uptake. Interventions include pushing passive design principles and thermally efficient materials for redevelopments and retrofitting drives with cool roofs, reflective paints and shading devices and working on their market feasibility.

Microclimate enhancement becomes important for Jaipur's landmarks and nodes considering high tourist influx in the city. Increasing tree canopy, fountains, permanent and retractable UV-resistant shading devices, use of low-heat absorption materials in pavements are some of the key measures. Bodies that regulate urban design and architecture in Jaipur like Jaipur Development Authority, Jaipur Municipal Corporation and UNESCO World Heritage Committee are crucial for planning and implementation.

Jaipur regional boundary
Jaipur urbanisable area (U1)
Jaipur city boundary

GREEN AND BLUE INFRASTRUCTURE INTENSIFICATION ZONE
Green area
Waterbodies and waterways

PRIORITY FOR COOLING INTERVENTION
Low
Medium
High

RENEWABLE ENERGY SOURCES
Potential solar energy generation areas
Residential
Commercial
Public-semi public
Industrial

Other renwable energy generation sources
Location of dairy farms
Location of gaushalas
Landfill sites
BioCNG plant
Location of waste transfer station
Location of brick kilns
Agriculture land

N

0 5 10 20 30 40 km

Priority for cooling interventions
Low
Medium
High

0 2 4 8 10 14 km

Cooling solutions in outdoor spaces

Misting system at bus stop

Shaded pathway

Tree canopy shaded urban street

Energy and Technology Intervention Zone

This zone addresses the spatial and technological dimensions of active cooling systems, focusing on modern performance standards and their optimal placement within the urban fabric and associated renewable energy installations.

City-level solar generation has potential to offset 35 per cent of the total residential cooling load in projected scenarios of 2037. Similarly various other renewables energy streams like biomass, municipal waste and waste heat from industries, ambient environment and geothermal energy can substantially offset local cooling loads.

Technology intervention zone

This zone is identified based on compatibility of land uses, their energy use and socio-economic status of wards. These interventions involve development of infrastructure and delivery of Cooling as a Service in redevelopment and retrofitting to accommodate cooling technologies that are more suitable, efficient and economically feasible considering future advancements.

Jaipur city boundary
Aravalli dominated wards

Feasibility for technology integration
Low
Medium
High

N

0 2 4 8 10 14 km

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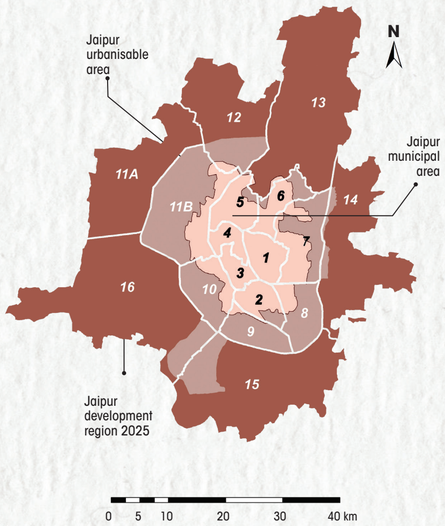
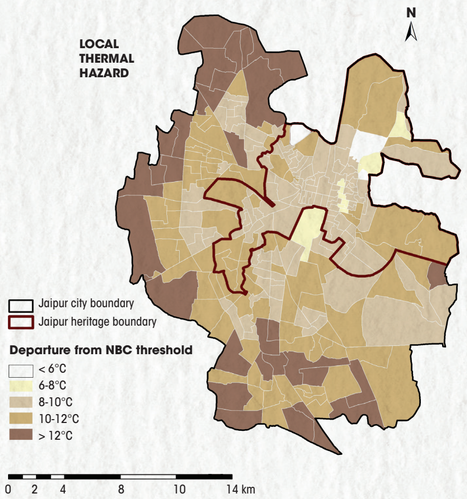


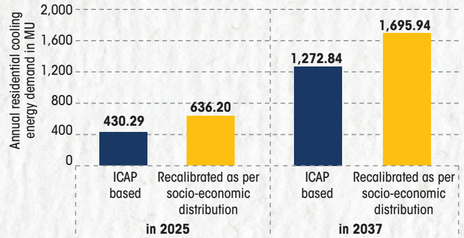
Thermal Hazard in Jaipur

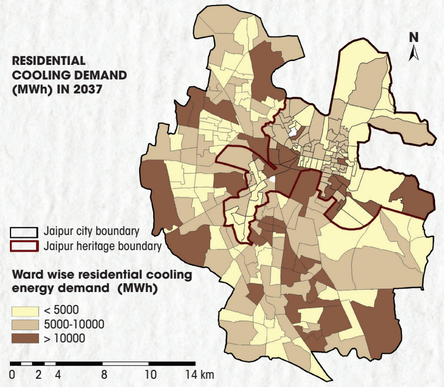
- Jaipur's 250 wards face different levels of heat. This is primarily driven by the intensity of built-up fabric, lack of green-blue infrastructure, and other related anthropogenic activities.
- India's National Building Code 2016 - Model for Adaptive Comfort - sets Jaipur's ambient air temperature threshold at 35.5°C to provide indoor thermal comfort to its citizens at 32°C.
- Departure from this threshold was classified into five thermal zones based on temperature delta: Zone 1 (<6°C), Zone 2 (6-8°C), Zone 3 (8-10°C), Zone 4 (10-12°C), and Zone 5 (>12°C).
- Jaipur's 13 per cent of wards fall in Zone 4 and Zone 5, which represent high and extremely high heat intensity. 35 per cent fall in Zone 3 (moderate-high) and 48 per cent in Zone 2 (moderate-low) heat intensity. This thermal hazard mapping informs ward-level heat action priorities.



Cooling Energy Demand Projections

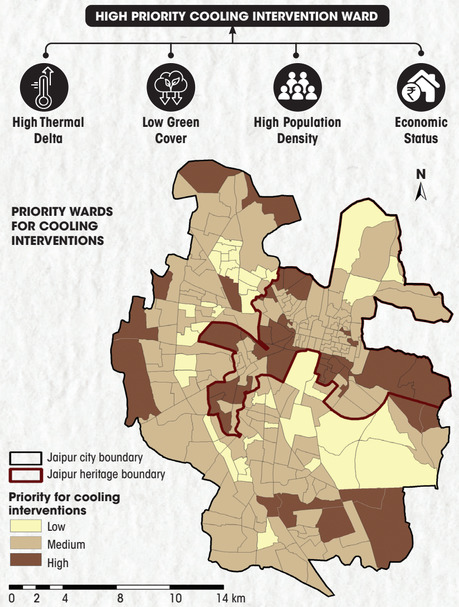
CSE estimated that residential space cooling in Jaipur will more than triple by 2037 (approximately 1,700 MU from the current level of 450 MU). Two methodologies were selected: one considering the India Cooling Action Plan (ICAP) and the other considering socioeconomic variabilities. Both methodologies were applied to respective AC penetration rates and associated cooling demand, and later normalized to arrive at demand projections. Further, commercial cooling demand could reach 800 MU by 2037.





Prioritisation of Wards for Cooling Interventions

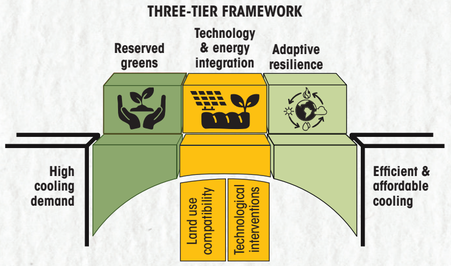
- A prioritization matrix was developed based on the integration of four primary factors: thermal delta, population density, green-blue infrastructure, and economic status across 250 wards of Jaipur.
- The matrix yielded 38 high-priority wards and 172 medium-priority wards where interventions will be critical to arrest Jaipur's growing cooling demand.
- 88 per cent of these wards are dominated by low-income households, demanding cooling equity considering the ICAP goal of thermal comfort for all.

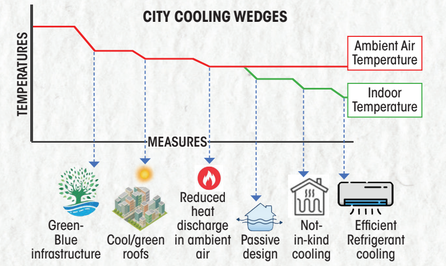


Urban Cooling Framework: A Three-Tier Strategy

Jaipur faces mounting heat stress that threatens public health, productivity, and quality of life. To restore the city to ambient temperature thresholds established by the National Building Code (NBC), a comprehensive three-pronged cooling strategy is essential—one that safeguards existing green and blue infrastructure while integrating time-tested passive design principles with innovative energy and technology solutions tailored to the city's unique urban landscape.

This framework draws upon Jaipur's centuries-old wisdom in heat-resilient architecture and combines it with contemporary climate science to create an equitable, sustainable cooling paradigm for the modern city.





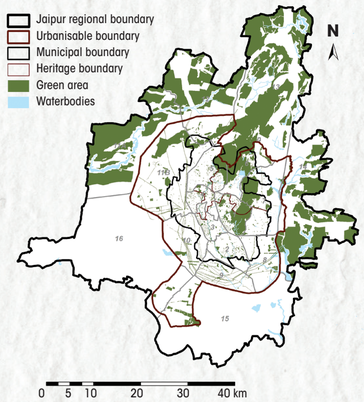
Tier 1: Green and Blue Infrastructure – Natural Coolth

The first tier focuses on recognizing and amplifying the inherent cooling potential of Jaipur's natural resources. Green spaces, waterbodies, and ecological corridors provide essential ecosystem services that regulate urban temperatures, yet these assets face increasing development pressure.

Strategic Approach

This tier requires strengthening the regulatory framework through revised bylaws, economic instruments, and spatial planning policies that explicitly value environmental goods and services. By quantifying the cooling benefits of parks, lakes, and tree canopy in economic terms, such as transferable development rights, we can build the case for their protection and enhancement within urban development plans. Zoning regulations, transferable development rights, and green infrastructure mandates must be recalibrated to preserve the spatial integrity and ecological functionality of these natural cooling systems.

The goal is not merely conservation but strategic expansion—creating interconnected networks of green and blue infrastructure that maximize cooling effects across neighborhoods, with particular attention to heat-vulnerable communities.



Tier 2: Adaptive Resilience – Learning from Heritage

Jaipur's historic built environment has withstood harsh climatic conditions for centuries through ingenious passive design strategies. This tier seeks to translate traditional cooling wisdom into contemporary development practices, ensuring that modern construction benefits from time-tested principles of thermal comfort.

Strategic Approach

Key interventions include promoting cool roofs and reflective materials, optimizing building orientation and shading, enhancing thermal insulation, and incorporating natural ventilation principles derived from Jaipur's architectural heritage. These passive measures reduce indoor temperatures while moderating outdoor heat island effects, creating comfort both inside buildings and in surrounding public spaces.

Crucially, this tier emphasizes equity and accessibility. Through carefully designed cross-subsidization mechanisms linked to carbon credits and climate finance, cooling interventions can be extended to economically disadvantaged communities that bear disproportionate heat burdens. Socioeconomic mapping will identify priority zones where passive cooling retrofits can deliver maximum social benefit, ensuring that climate adaptation serves the entire urban population.

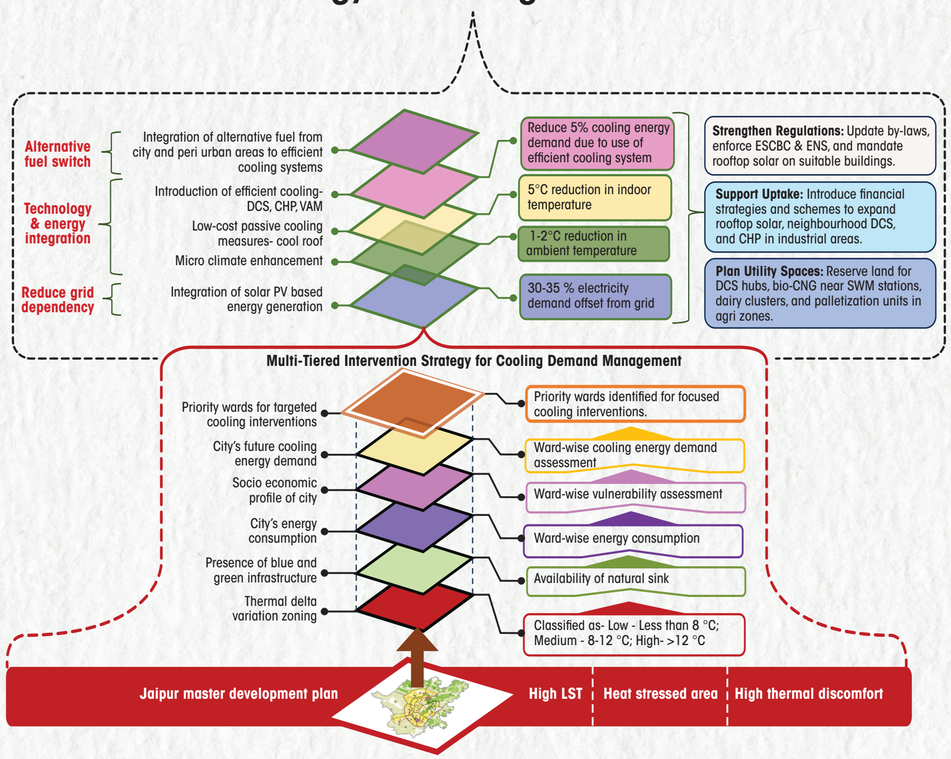
Tier 3: Energy and Technology Integration

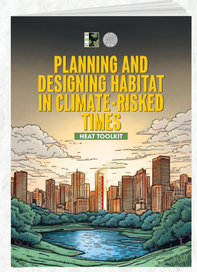
The third tier addresses the spatial and technological dimensions of active cooling systems, focusing on modern performance standards and their optimal placement within the urban fabric. As demand for mechanical cooling grows, strategic planning becomes essential to manage energy loads, ensure equitable access, and minimize environmental impact.

Strategic Approach

This tier employs land use compatibility analysis and proximity mapping to identify zones where district cooling systems, renewable energy installations, and efficient cooling technologies can be most effectively deployed. By integrating these findings into Town Planning (TP) schemes, development regulations and creating incentives for renewable energy-powered cooling solutions, we can create enabling conditions for innovative delivery models such as "Cooling as a Service"—where centralized, efficient cooling infrastructure serves multiple buildings or neighborhoods through shared networks.

Methodology for Enabling Thermal Comfort





This urban cooling framework is a planning approach to bundle sustainable and equitable cooling solutions for rapidly transforming urban regions in a warming world. It involves safeguarding existing green and blue infrastructure while integrating time-tested passive design principles with innovative energy and technology solutions for the modern city. This sets a platform for spatial and technological integration for cooling which could be adopted in GIS-based master plans to ensure energy security, cooling equity and local co-benefits of better liveability, air pollution and heat mitigation.

This work is a continuation of the Heat Toolkit for Planning and Design of Habitat in Climate Risked Times which gave a methodology to evaluate heat stress at the city, neighbourhood and local scales based on the impact of land-use intensity (private vehicles, air conditioners, industries, etc.) and anthropogenic activities.

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