URBAN HEAT ISLAND EFFECT: THREAT TO MAJOR INDIAN CITIES

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Abstract

The Urban Heat Island effect is a mounting threat for public health and environmental sustainability. Due to this effect cities and metropolitan areas have significantly higher temperatures, sometimes 2-10 degrees higher than neighbouring suburban or rural areas. Cities built with heat absorbing materials like asphalt and concrete, dense concrete constructions with narrow roads along with heat-emitting appliances like air conditions worsen the effect. To address the problem of UHIs different Indian cities are implementing Heat Action Plans with definite local strategies. Smart city planning, nature-based solutions, passive cooling strategies can be the way forward in tackling UHI effect. Urban planners and city architects must develop targeted solutions that improve thermal comfort, reduce energy demand and create sustainable cities which are resilient and climate adaptive.

Keywords: sustainable cities, climate resilient, Heat Action Plans, micro climate, cooling strategies

Urban Heat Island Effect

Urban Heat Island (UHI) is a common phenomenon globally but is especially an existing threat to major Indian cities. The cities in India lack proper planning and urban green spaces as a result are easy victims of Urban Heat Island Effect. Due to this effect cities and metropolitan areas have significantly higher temperatures, sometimes 2-10 degrees higher than neighbouring suburban or rural areas. Urban Heat Islands are formed largely due to senseless anthropogenic activities as destruction of green cover and filling up of natural water bodies. Cities built with heat absorbing materials like asphalt and concrete,

dense concrete constructions with narrow roads along with heat-emitting appliances like air conditions worsen the effect. UHI effect and climate change amplify each other resulting in worsening of public health and quality of life for urban dwellers (Parker, 2010)

Urban Heat Island Types

A. Surface UHI

This is also called remotely sensed UHI as infrared data is used for observations and retrieval of surface temperature. The surface UHI values vary seasonally and are found to be higher in summer due to higher incoming solar radiation and dry conditions

B. Atmospheric UHI

1. Canopy layer UHI

This refers to the layer of air inhabited by humans and extends from the ground to below the tops of vegetation and roofs

2. Boundary layer UHI

This layer extends from the roof top levels to the point where urban landscapes have no effect on the atmosphere.

C. Micro UHI

This is a localized climatic effect where certain urban areas record higher temperatures than their surrounding urban areas such as buildings with poor ventilation, parking lots, non reflective roofs, larger number of air conditioners, asphalt roads with little or no greenery. A study conducted in Chennai revealed that industrial areas, dark surfaces, automobiles aggravate micro UHI. Width of roads, distance between buildings, building heights affects micro UHI.

Key Reasons for UHI Effect in India

Cities have turned to islands of heat due to several man-made environmental factors (Mohan *et al.* 2022)

i. **Heat Absorbing Materials** : Dark coloured concrete and asphalt have poor reflectivity and absorb and store large quantities of heat

ii. **Loss of Green-Blue Infrastructure**: Unchecked and uncontrolled urbanization has destroyed greenery and blue water bodies giving rise to poor shading and low evapotranspiration (Sen, 2020a; 2022).

iii. **Urban Geometry**: Urban canyons are created due to skyscrapers and narrow roads. Natural ventilation is restricted and the heat is trapped and repeatedly reflected.

iv. **Waste Heat** : Densely populated cities generate a lot of waste heat from industries, automobiles and air conditioners

Major Impacts on Cities

i. **Severe Night time Temperature :** Cities do not cool down even at night so there are severe health risks. Heat stress does not allow the people to recover from the daytime temperature.

ii. **Public Health Risks**: Urban-labourers, the homeless and those living in informal settlements face critical sometimes fatal conditions during peak summer.

iii. **Rising Energy Demand** : High temperatures lead to higher energy demands with extensive use of air conditioners, which in turn produces larger amounts of waste heat creating a dangerous feedback loop

iv. **Air Pollution**: Stagnant hot air and lack of green cover aggravates ground level ozone production worsening the situation due to severe smog and poor air quality.

Heat Stress on Urban Population

According to the Indian Meteorological Department, Indian heat wave days have more than doubled since 1980. The economically backward, the migrant labourers along with the urban slum dwellers fully bear the impact of heat waves. According to the Census of 2011, almost 65 million Indians which is about 17% of the urban population live in slums. Such areas are marked by tin or asbestos roofs, inadequate ventilation, overcrowding with little or no open space. Large families living in single room homes undergo dehydration, sleep deprivation and heat exhaustion. Absence of uninterrupted electricity and water deepens the crisis. Storing water in plastic containers aggravates indoor heat. Rising cost of electricity and healthcare with declining productivity worsens the economic crisis (Yang *et al.*2016)

Migrant labourers working in construction sites, street vendors, sanitation and delivery services are exposed to extreme temperatures. Prolonged hours of exposure to high

temperatures lead to heat exhaustion, dehydration and heat stroke all of which can turn fatal. Aggravation of cardiovascular and respiratory diseases occurs due to high ozone and particulate matter. Deterioration of mental health, sleep quality and work productivity. According to National Disaster Management Authority extreme temperatures can reduce work productivity and efficiency by 15-20%. For daily labourers loss of working days lead to financial loss thus putting families in graver crisis. WHO has identified the urban poor as the most climate-vulnerable requiring urgent interventions.

The Global Scenario

Cities like New Delhi, Ahmedabad, Hyderabad, Pune, Mumbai and Kolkata faced severe heat waves in 2024 indicating the rising threat of UHIs. While New Delhi easily became the epicenter of urban heat stress the other metropolitans too did not lag behind. The scenario clearly indicated global climate change and urban heat mismanagement (Islam, 2024). The UHI effect magnified the crisis converting the metropolitans into heat traps deteriorating health, productivity and quality of life (Biswas and Sen, 2025; Pramanik and Sen, 2025). The summer of 2024 was one of record-breaking heat with New Delhi surpassing 46^0C and the Indo-Gangetic plain under severe heat wave.

The IPCC Sixth Assessment Report (2023) delineates South Asia as one of the most heat prone regions of the world. The Indian National Disaster Management Authority has formally declared heat waves as national disaster, signaling the urgent need for adaptive, community-centric improvement strategies. At the Conference of Parties (COP) 30 in Brazil living on a hotter planet with the main adaptation strategies are the focal points of discussion. SEEDS (Sustainable Environment and Ecological Development Society) has initiated a community-centric approach to heat resilience particularly in New Delhi that is pertinent to the Global South. The importance of these initiatives was brought into focus in the G20 Ministerial Declaration on Disaster Risk Reduction which approved the adoption of 'Resilience of All.'

Strategies for Mitigation of UHIs

To address the problem of UHIs different Indian cities are implementing **Heat Action Plans (HAPs)** with definite local strategies.

i. **Vegetation and Green Infrastructure**: Increasing urban greenery through parks, gardens, green spaces etc. which act as heat sinks Sen, 2023a). Increasing the tree canopy by planting native shade trees in parking areas, pavements and pedestrian paths, avenues and others provides cooling through evapotranspiration (Sen, 2020b; Yuan *et al.* 2026)

ii. **Reviving Water Bodies** : Restoration of water bodies will help in cooling as creation of ponds, lakes and fountains cools the microclimate

iii. **Green Roofs and Walls** : Creating green roofs and walls prevents heat absorption (Sen, 2023b)

iv. **Reflective and Permeable Surfaces**: Using white or highly reflective substances prevent absorption of heat. Replacing dark asphalt and concrete with high-albedo materials will be an effective measure.

v. **Urban Design and Ventilation**: Designing layout of streets so that wind corridors are created pushing out trapped heat. Building orientation and shading must be optimized so that there is protection from incoming solar radiation.

vi. **Policy and Resource Equity**: City planning to be done with great care emphasizing green space ratios, cool roof and green wall regulations and other shading requirements. There must be targeted interventions in localities of low-income and marginalized groups.

vii. **Anthropogenic Heat Reduction**: This consists of energy-efficient designing of buildings with improved insulation and natural ventilation to minimize the dependence on AC units producing excessive waste heat. Sustainable transportation needs to be promoted using energy-efficient vehicles.

The Way Forward

The UHI effect is a mounting threat for public health and environmental sustainability. Smart city planning, nature-based solutions (Sen, 2026), passive cooling strategies can be the way forward in tackling UHI effect. Urban planners and city architects must develop targeted solutions that improve thermal comfort, reduce energy demand and create sustainable cities which are resilient and climate adaptive (Sen, 2022). Implementation of smart-city strategies will then go a long way to build healthier and more sustainable urban environments.

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