Accelerated Delhi Heat Action with Artificial Intelligence (AI) and Machine Learning (ML)

Haripriya Kesavan[1], Meghna[1], Samhita R[1], Mrinalini Srivastava[2]
1 Resilience AI, India, haripriya@resilience360.ai, meghna@resilience360.ai, samhita@resilience360.ai
2 IPS Director National Disaster Management Authority, Ministry of Home Affairs, Government of India, mridus007@gmail.com

Abstract

Rising global temperatures are driving an increase in extreme heat events, which threaten public health, strain infrastructure, and disrupt daily life in cities worldwide, including India, where rapid urbanization, dense built environments, and socio-economic disparities amplify vulnerability. Among India's urban centers, the national capital, Delhi stands out as a critical heat hotspot, shaped by pronounced urban heat island effects and uneven socio-spatial exposure. The Delhi Heat Action Plan (DHAP) 2025, envisioned by the National Disaster Management Authority (NDMA) is anchored on the state disaster database guideline of Disaster Management Act 2005, serves as a city-wide, multi-scalar framework to combat extreme heat by integrating scientific assessments, local context, and targeted interventions. To support DHAP's data-driven planning, this study presents Resilience360™, a disaster decision system using Artificial Intelligence (AI) and Machine Learning (ML) to conduct heat assessments through a scientific evidence-based approach. The platform incorporates locations with diverse urban morphologies and socio-economic profiles, selecting four representative areas for hyperlocal heat risk assessment. These represent a mix of transit nodes, administrative hubs, and residential areas with distinct risk profiles. The analysis utilizes built-environment datasets and building structural typologies across all four heat-vulnerable regions. Integrating multi-stack technology with on-ground action, Resilience360™ serves as a tool to inform DHAP's strategy by identifying micro-hotspots of heat exposure. The system classified buildings into five risk categories based on exposure, structure, and building materials, revealing most mapped structures as high to moderate risk. The resulting risk maps guided ground-level surveys, helping field teams visually identify high-risk areas and prioritize buildings for on-ground validation and accelerate structural intervention implementation. Its modularity and use of scalable datasets make it replicable across other heat-vulnerable Indian cities. This study highlights the potential of AI and ML-driven granularized intelligence to strengthen inclusive and climate-resilient urban governance, offering a scalable playbook for addressing heat risks through science and technology integration.

Keywords: Artificial Intelligence, Machine Learning, Hyperlocal Heat Risk Assessment, Climate Resilience, Urban Heat Island Effect

Introduction

The escalating heat crisis in Delhi presents a significant challenge to urban infrastructure resilience. Urban areas globally are increasingly vulnerable to intensifying climate challenges, particularly extreme heat events (Calvin, 2023). This paper presents an innovative, Artificial Intelligence (AI) and Machine Learning (ML)-based decision support system designed to enhance urban resilience by minimizing the "cost of inaction" and expediting “speed of mitigation intervention” throughout the year as heat preparedness initiative. Delhi experiences extreme summer conditions, marked by intense heat and exceptionally high temperatures, often approaching 45°C during peak months. Delhi is highly susceptible to the impacts of heatwaves, primarily due to its dense population and significant proportion of low-income communities (Delhi Heat Action Plan, 2025). Remote sensing plays a critical role in heat risk assessment and enables monitoring of land surface temperature, vegetation, and built-up areas (Diem et al., 2024). Machine learning algorithms have emerged as powerful tools for heat risk assessment of each building and land parcel, with detection and classification of buildings, processing satellite imageries, indices, and complex geospatial datasets (Castro et al., 2025) (Ghorbany et al., 2023). This study demonstrates the transformative potential of science and technology integrated hazard, vulnerability and risk (HVRA) intelligence, using RISE™ design principles viz., reliable (accuracy), integrated (multi-variate datasets and technology stack), simple (accessible) and effective (decisions) towards addressing urban heat vulnerability for various locations in Delhi.

AI and ML Powered Disaster Risk Assessment for Heat

The research focuses on the detailed climate risk assessment for primarily four identified locations in Delhi. A proprietary enterprise software, Resilience360™, was utilized to deploy hyperlocal heat risk assessment for the Delhi Heat Action Plan. The assessment was conducted using high-resolution satellite imageries, geo climatic and geo-spatial datasets, and thereby assigns scores to indicate hyperlocal level of heat risk. The assessment analyses severity of risk for each building in the identified area of interest. The generated structure-level risk scores across four diverse urban zones helped with informed field visits for the surveyors. The multi-variate parameters integrated into the heat risk algorithm influencing the risk scores can be classified as follows:

Building footprint detection and structure characteristics

Using satellite imagery (512 × 512-pixel tiles) was processed using a U-Net segmentation model with an Efficient Net-based encoder to extract precise building and neighbourhood footprints. The output is used as base spatial layer for localized heat risk assessment. This method allows the assessment of building-level sensitivity to excessive heat.

Building material typology

To classify building material typologies across urban structures, a convolutional neural network (CNN) was used, which has been shown to be effective at extracting spatial data. The machine was trained using a curated dataset of structural components of building, to meet input dimensionality requirements. The model had an overall classification accuracy of 84.64%, indicating strong detection performance across diverse building clusters. Accurate structural identification was critical for assessing surface heat absorption characteristics, determining risk differentials in heat exposure, and developing targeted mitigation solutions such as cool roof installations and albedo enhancement interventions.

Climate and environmental datasets

The spatial and climatic datasets used for the heat assessment include LST (Land surface temperature), water lines, water bodies and Normalized Difference Vegetation Index (NDVI).

The parameters are integrated using Analytical Hierarchy Process (AHP) with the input geo-climatic datasets. The risk profile with a composite heat risk score is generated at a building level. The risk scoring is on a scale of 1 (very low) to 5 (very high), showing the exposure of all detected buildings in the target region, along with corresponding percentage of buildings at risk for the neighboring area.

Locational Characterization: Study Area

Through a series of hyperlocal heat risk assessments conducted in four critical areas of Delhi, each selected for its unique urban built form and critical relevance to heat risk (See Figure 1). Firstly, a densely populated low-income settlement Sultanpuri, in northwest of Delhi, is characterized by compact housing, minimal green cover, and high social vulnerability. Second, a notified slum Kalakunj within the otherwise planned Shalimar Bagh sub-zone, reflects intra-ward disparities, with unplanned housing, poor ventilation, and limited access to cooling infrastructure. Followed by two high-footfall transit hubs Anand Vihar ISBT in eastern and Maharana Pratap ISBT northern Delhi are dominated by impervious surfaces and intense anthropogenic heat.

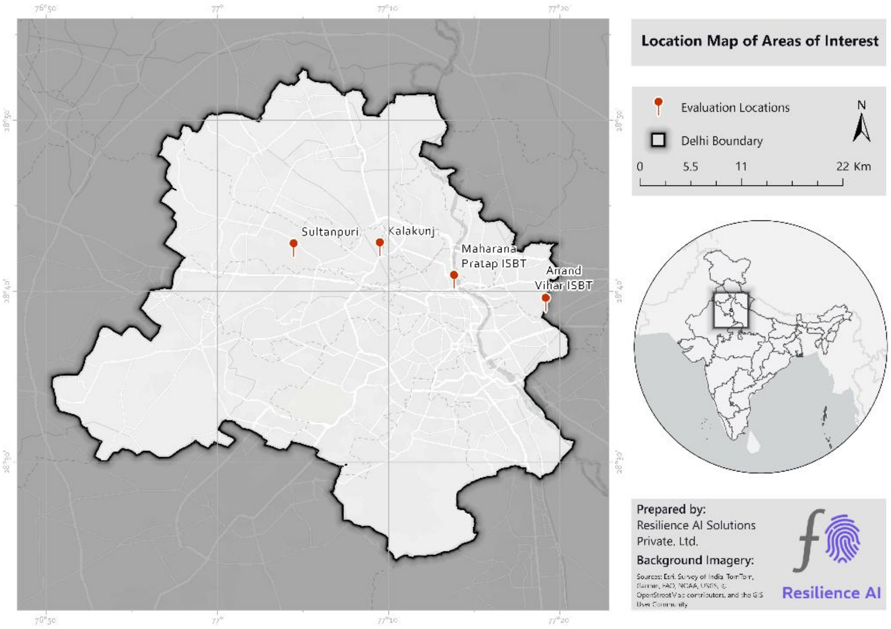

Figure 1 Location Map of Area of Interests in Delhi

Spatial Analysis and Model Output

Heat risk profiling using Resilience360™, nearly 8,346 buildings across four areas in Delhi were classified into five risk categories, whereby majority of buildings were concentrated in higher-risk zones, 65% identified as Very High Risk, 32% as High Risk, and 3% as Moderate Risk. Shalimar Bagh (including Kalakunj) is distributed between very high and high risk classes at 51% and 43% of identified built structures respectively (See Figure 2). The ISBT transit hubs, Maharana Pratap at 85% at high risk (See Figure 4) followed by Anand Vihar ISBT exhibiting the highest concentration at 96% with high risk (See Figure 3). The heat risk assessment for Sultanpuri reveals a high susceptibility to heatwaves, with 90% are at very high risk from heatwaves as emissions scenarios intensify, heatwave risks escalate sharply (See Figure 5).

The results were instrumental in planning and resource allocation for targeted on-ground field surveys in the Delhi Heat Action Plan.

Figure 2 Heat risk assessment map for Kalakunj, Shalimar Bagh

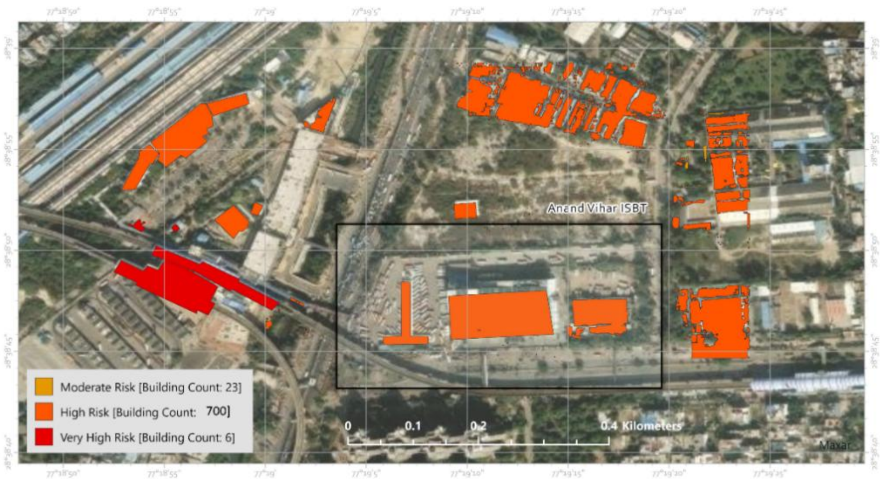

Figure 3 Heat risk assessment map for Anand Vihar ISBT

Figure 4 Heat risk assessment map for Maharana Pratap ISBT

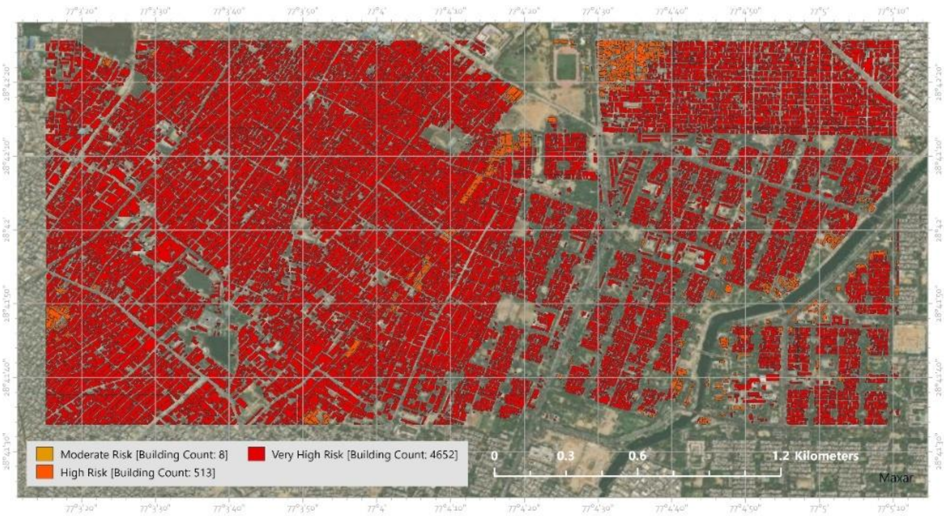

Figure 5 Heat risk assessment map for Sultanpuri

Conclusion

Resilience360™ successfully assessed 8,346 buildings across four diverse locations in Delhi for Heat Action. Hyperlocal climate (heat) risk assessment is integral to quantifying surface heat absorption characteristics, informing risk differentials in heat exposure, and enabling accelerated and targeted mitigation interventions such as cool roof installations and cooling infrastructure. The scalable methodology offers practical applications for enhancing urban resilience planning and informing evidence-based policy recommendations.

References

1. Calvin K, Dasgupta D, Krinner G, Mukherji A, Thorne PW, Trisos C, Romero J, et al. IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. 2023;34. doi:10.59327/ipcc/ar6 9789291691647.001.
2. Diem, P. K., Nguyen, C. T., Diem, N. K., Diep, N. T. H., Thao, P. T. B., Hong, T. G., & Phan, T. N. (2024). Remote sensing for urban heat island research: Progress, current issues, and perspectives. *Remote Sensing Applications: Society and Environment*, *33*, 101081.
3. DHAP, 2025. NDMA, *Delhi Heat Action Plan*
4. Castro, J. R. R., & Delina, L. L. (2025). Integrated policy and AI-assisted technologies to address extreme heat and enhance urban resilience. *Journal of Environmental Studies and Sciences*, 1-15.
5. Ghorbany, S., Hu, M., Yao, S., & Wang, C. (2024). Towards a sustainable urban future: A comprehensive review of urban heat island research technologies and machine learning approaches. *Sustainability*, *16*(11), 4609.