Urban Heat Map for Stray Animals: Pilot Study in Bandra, Khar and Santacruz, Mumbai

Rihaan Sodhani

3 July 2026

Executive Summary

The urban heat island effect has resulted in significantly increased temperatures in cities such as Mumbai compared to nearby rural areas. This heat burden poses a serious, largely unaddressed risk to street animals, which face increased risks of dehydration and heatstroke. However, water bowl placement for street animals today is driven by informal, volunteer-led effort rather than any data-informed assessment of where heat exposure is greatest. Hence, this project addresses this gap, using Landsat 8 satellite thermal imagery and geospatial safety screening to develop a reproducible methodology for identifying water bowl placement locations. The study has been piloted across Mumbai's H/West and H/East wards, but the methodology can be expanded to cover a larger region. Using land surface temperature data from March–May 2025, the pilot identified elevated-heat zones aligning with major roads and railways, while cooler regions lay in residential areas near the coast. 14 candidate locations were identified for potential intervention, screened against hazardous areas, including railways, roadways, and water bodies; the number of water bowls can be set based on ward animal population data or available implementation capacity. These points recorded a mean surface temperature 2.08°C above the pilot area's overall average, confirming the methodology reliably targets genuine thermal hotspots. The outputs of this study are intended to serve organisations such as the Brihanmumbai Municipal Corporation, Non-Governmental Organisations, and local animal welfare organisations to guide heat action planning or volunteer-led placement.

1. Introduction

The urban heat island effect

The urban heat island (UHI) effect refers to the phenomenon in which cities are warmer than nearby rural areas. Rapid urbanisation has significantly increased temperatures in megacities such as Mumbai.[1] Measured land surface temperatures range from 28–34°C in Mumbai, in contrast to 21–23°C in the vegetated outskirts of the cities.[2] Major contributing factors to this phenomenon include the properties of urban infrastructure and reduced vegetation and open space.

Impact on urban street animals

The effect of the UHI effect on urban stray animals is a problem that goes under-addressed. The higher temperatures significantly increase the risk of dehydration, heat stress, and

heatstroke in urban dogs, cats, cows, and other animals. They are often more vulnerable to heat stroke than humans, leading to high mortality rates, up to approximately 50% in canines.[3] This is not a marginal population: 2024 reports indicate that the population of street dogs in Mumbai is approximately 90,757.[4] Hence, for animals with no owner to provide shade, water, or emergency care, dehydration and heat stress during Mumbai's hottest months is an important concern.

Problem statement and objective

Despite this documented risk, water bowl placement for street animals in Mumbai today is driven largely by informal, volunteer-led effort based on where residents or feeders happen to be. There is currently no publicly available, data-driven framework that identifies where heat risk is concentrated. This project addresses that gap directly by using satellite-derived land surface temperature (LST) data and geospatial safety screening to generate a reproducible, evidence-based shortlist of water bowl locations.

2. Methodology

Data sources

Three independent data sources were used, as described in Table 1.

Table 1. Summary of data sources used.

Data source	Purpose	Resolution
Mumbai administrative ward boundaries[5]	Study area definition	N/A
Landsat 8 Collection 2 for March–May 2025[6]	Land Surface Temperature (LST)	30m
OpenStreetMap[7]	Hazard infrastructure (railways, highways, and water bodies)	N/A

Study area

The pilot area consists of Bandra, Khar and Santacruz, specifically Mumbai’s H/West and H/East administrative wards. Across these two wards, the population of stray dogs has been estimated to be 1166 in 2024 reports, making this an important region for the project.[4] The ward boundaries were sourced from a GeoJSON file hosted in a third-party GitHub repository of Mumbai spatial datasets, and the two wards were merged into a single Area of Interest (AOI) polygon for all downstream processing.[5]

Land surface temperature

LST was derived from Landsat 8 Collection 2, accessed via Google Earth Engine, for March–May 2025 (Mumbai's pre-monsoon hot season).[6] Though absolute LST will vary

throughout the year, the trends in the UHI effect, including identified hotspots relative to surrounding areas, are expected to remain similar because they arise from fixed characteristics such as infrastructure, building density and impervious surface cover.

This source provided 30m resolution, making it effective to identify specific hotspots. Available scenes within the study window were filtered to a cloud-cover threshold of under 40% and cloud-masked at the pixel level. The resulting scenes were combined into a single median composite to reduce the influence of any single anomalous observation.

Heat classification

Each pixel within the AOI was classified relative to the AOI's own mean LST, computed across the full study area: pixels above this mean were classified as elevated-heat zones. A locally-derived relative threshold was used in preference to a fixed absolute temperature cutoff, as absolute LST values are sensitive to season and atmospheric conditions.

Safety exclusion criteria

Candidate locations were screened against three categories of hazard infrastructure, sourced from OpenStreetMap:[7] railway lines, major roadways, and water bodies. Railway and roadway geometries were buffered by 30 metres to create exclusion zones and hence ensure the safe placement of water bowls.

Candidate point selection

Within each ward's elevated-heat zone, candidate locations were generated through random spatial sampling, followed by a point-in-polygon validation against the ward boundary and exclusion of any candidate falling within the safety buffer.

Mapping and visualisation

A heat map was visualised for the pilot region. Spatial outputs were rendered using geemap, a Python interface to Google Earth Engine,[8] with an OpenStreetMap basemap providing street- and building-level geographic context.[7]

3. Results and Discussion

The identified safety exclusion zones are shown in Figure 1.

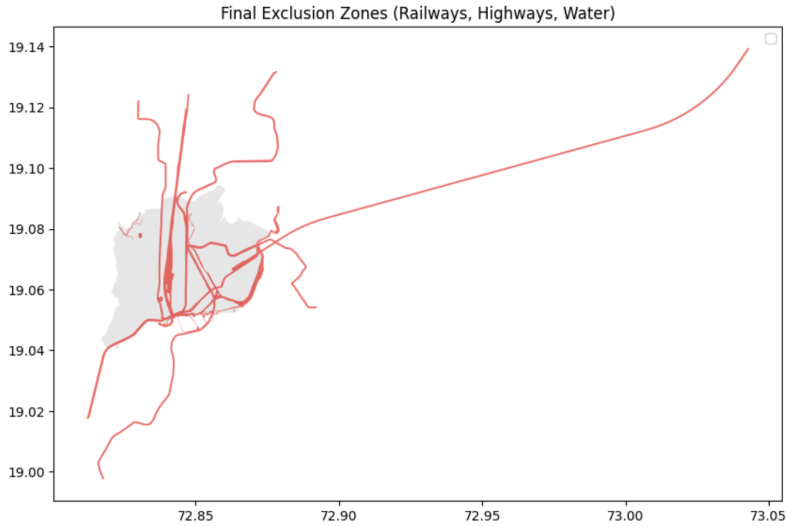


Figure 1. The identified safety exclusion zones. Railways, major roadways, and water bodies are shown (red), with 30m buffer zones around railways and motorways.

The boundary for the pilot area (Mumbai's H/West and H/East administrative wards), the identified elevated-heat zones, and the recommended water bowl placements are shown in Figure 2. The resolution of the map is high (30m), and the proposed intervention locations are precise, as shown in Figure 3.

In the pilot region, the largest zone with below-mean LST was found to lie near the coast in the West. This is consistent with lower building density (as this is a residential area), more tree cover, and proximity to the sea breeze off the Arabian Sea. The heat was observed to be concentrated in a north–south spine through the middle of the region. This corridor tracks closely with the Western Railway line and the major road corridors.

14 candidate points were chosen for the pilot, but this number can be adjusted based on available resources and ward animal populations. The mean LST across all 14 candidate points is 41.98°C, a difference of approximately 2.06°C compared to the average of the entire region in March–May 2025, which was found to be 39.92°C. Hence, the selected points lie significantly above the area's typical LST, supporting the pipeline's ability to identify hotspots.

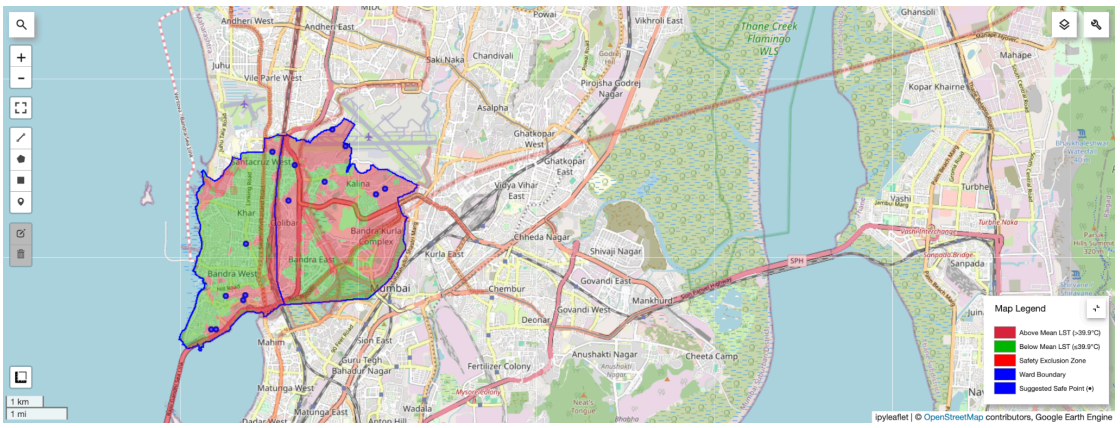
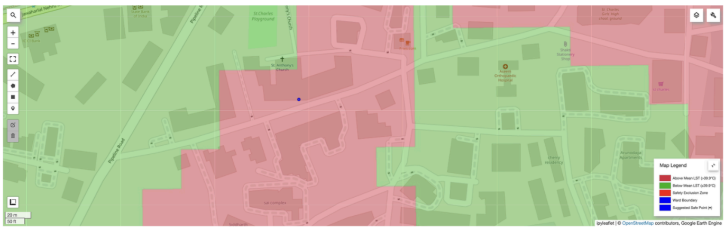


Figure 2. The heat map of the pilot region. The combined boundaries of Mumbai's H/West and H/East administrative wards are shown in blue. The elevated-heat zones with temperatures above the mean (39.92°C) are shown in red, while other zones are shown in green. The candidate intervention points are overlaid in blue.



(a) Representative zone 1



(b) Representative zone 2

Figure 3. Two representative enlargements from the heat map. They illustrate the 30m resolution of the LST data, shown in red and blue and the precision of the recommended intervention locations. Two locations are present in (a) and one in (b), shown as blue points.

4. Conclusion and Recommendations

Conclusion

In conclusion, this project addresses the objective of mitigating the impact of the UHI effect on urban stray animals. The pilot study developed and demonstrated a reproducible, satellite-data-driven methodology for identifying water bowl placement locations for street animals, applied to Mumbai's H/West and H/East wards. Using Landsat 8 thermal imagery, the study identified land surface temperature patterns across the pilot area, screened candidate locations against basic safety criteria, and produced a shortlist of 14 candidate locations.

These candidates sit meaningfully above the study area's average surface temperature, validating the approach.

Recommendations

The outputs of this study are intended to serve organisations such as the Brihanmumbai Municipal Corporation (BMC), Non-Governmental Organisations (NGOs), and local animal welfare organisations. For the BMC, this methodology offers a basis for integration into existing heat action planning and a candidate framework for citywide extension. For NGOs and local welfare organizations, the candidate location list is directly usable for volunteer-led placement and maintenance within the pilot area.

The methodology can be extended into other wards, requiring no modification beyond the availability of comparable thermal imagery and ward boundary data. However, prior to using this methodology to inform real action, it is important to determine the number of intervention points that will be used, and how to allocate water bowls across wards. One promising solution is weighing the allocation toward wards with both elevated thermal exposure and higher animal density, as can be determined from existing ward-level reports.[4] Alternatively, allocation could be set according to available implementation capacity, such as funding, volunteer availability, or operational reach.

Limitations and future scope

Certain limitations remain, which could be ameliorated as a part of this project's future scope. Firstly, the methodology could be expanded to incorporate other factors that influence the UHI effect, such vegetation cover or formal land-use classification. Additionally, candidate point selection could enforce a minimum spacing constraint to ensure that candidate points distribute evenly across the region studied. Finally, candidate coordinates have not been field-verified for practical accessibility or physical obstruction, and such verification is a necessary step before any location is used for physical bowl placement.

References

1. Manna H, Sharma R, Jha PK, et al. Urban heat in Mumbai: From scenario analysis to the future. *Journal of Urban Management*. 2026. doi:10.1016/j.jum.2026.02.008.

2. Grover A, Singh RB. Monitoring spatial patterns of land surface temperature and urban heat island for sustainable megacity: A case study of Mumbai, India using Landsat TM data. *Journal of Urban and Environmental Engineering*. 2016.

3. Nascimento PV, Veríssimo TNS, Soares WAA, Maia MIL, Carvalho LRRA, Saraiva EP. Heat stress in domestic dogs: morphological and environmental risk factors for dog welfare in a warming world. *Front Anim Sci*. 2025;6:1679377. doi:10.3389/fanim.2025.1679377.

4. OpenCity. Evaluation of street dog population management and sterilization impact in Mumbai – January 2024 [dataset]. Available from:

https://data.opencity.in/dataset/evaluation-of-street-dog-population-management-and-sterilization-impact-in-mumbai-jan-2024

5. Krishnan S. *Mumbai Spatial Data* [computer software]. GitHub. Available from: https://github.com/sanjanakrishnan/mumbai_spatial_data

6. Earth Resources Observation and Science (EROS) Center. Landsat 8-9 Operational Land Imager/Thermal Infrared Sensor Level-2, Collection 2 [dataset]. Reston (VA): U.S. Geological Survey; 2020. doi:10.5066/P9OGBGM6.

7. OpenStreetMap contributors. Planet dump retrieved from https://planet.osm.org [Internet]. 2017. Available from: https://www.openstreetmap.org

8. Wu Q. *geemap: A Python package for interactive mapping with Google Earth Engine*. *J Open Source Softw*. 2020;5(51):2305. doi:10.21105/joss.02305.