THE URBAN HEAT ISLAND CHANGE ANALYSIS OF CHENNAI FROM 2014 TO 2024

FINAL REPORT

Field	Details
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Abstract

This final report presents the Urban Heat Island (UHI) change analysis of Chennai from 2014 to 2024 using Landsat 8/9 Collection 2 Level 2 data processed in Google Earth Engine. The study compares March to May seasonal composites for both years to maintain similar summer conditions. Land Surface Temperature (LST), NDVI, NDBI, NDWI, UHI zone maps, and LST change maps were prepared to identify thermal variation and land-cover influence. The readable console statistics show that mean LST changed from 40.78 ℃ in 2014 to 39.55 ℃ in 2024, with a mean LST change of -1.23 ℃. The report also includes exact formulae, area calculations, map-output placement, console evidence, main findings, conclusion, and future scope.

Introduction

Urban Heat Island refers to the condition where urban areas show higher surface temperature than nearby natural or less built-up regions. Dense buildings, roads, concrete surfaces, low vegetation cover, traffic, industrial activity, and reduced evapotranspiration increase heat storage and surface temperature. Chennai is suitable for this study because it is a dense coastal metropolitan region with rapid urban development, transport corridors, residential expansion, industrial areas, and changing land cover patterns.

Remote sensing is useful for UHI studies because thermal satellite data can estimate land surface temperature over a large region. Google Earth Engine was used because it supports cloud-based processing of Landsat data, image filtering, cloud masking, median composite creation, index calculation, classification, area measurement, and map visualization without downloading large raw datasets.

Study Area

The study area is the land-only Chennai focus region in Tamil Nadu, India. Sea pixels were removed from the analysis because coastal water areas can reduce or distort the thermal statistics. The selected region covers the Chennai urban core and surrounding land portions within the defined spatial extent.

Parameter	Description
Location	Chennai focus region, Tamil Nadu, India
Spatial extent	Approximate bounding box: 80.05°E to 80.35°E and 12.75°N to 13.25°N
AOI type	Land-only Chennai focus region
Importance	Dense urban area, coastal setting, built-up expansion, vegetation variation, and visible thermal contrast

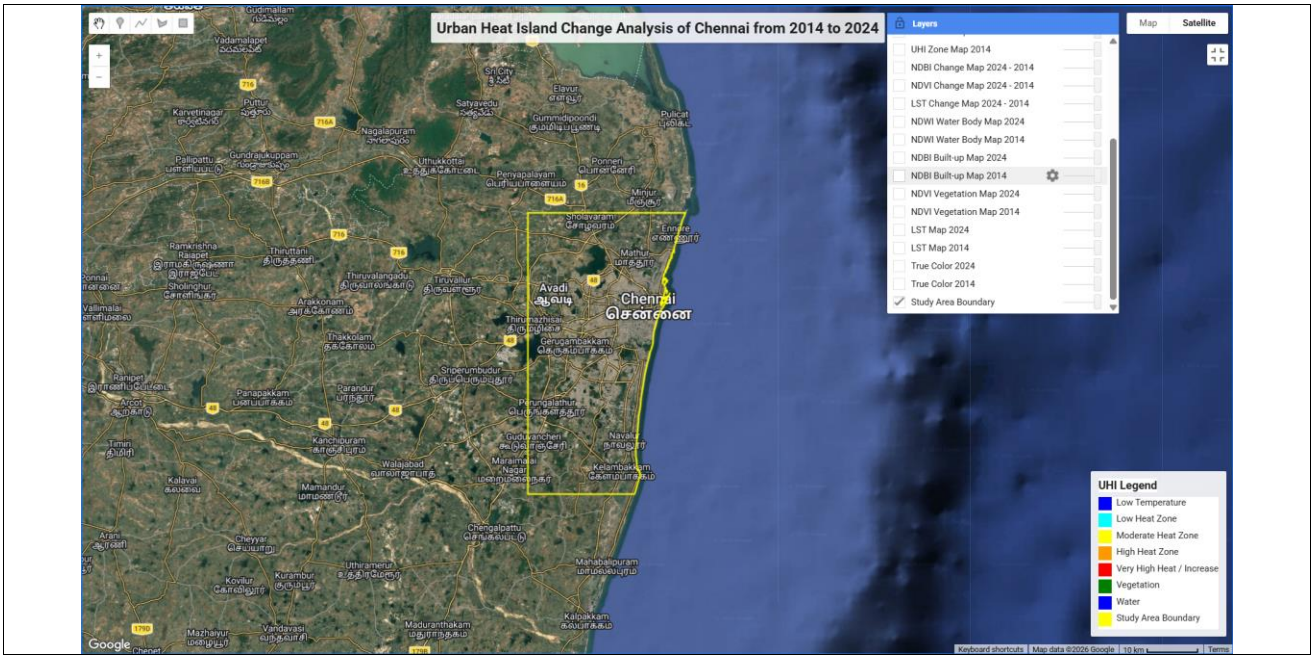


Figure 1. Study Area Boundary of Chennai

This figure should be placed in the Study Area section because it introduces the geographical boundary used for all calculations. It helps the reader understand the exact analysis region before viewing LST and UHI outputs.

Objectives

- To extract and compare land surface temperature of Chennai for 2014 and 2024.
- To classify Chennai into Low, Moderate, High, and Very High heat zones.
- To identify the influence of built-up area and vegetation on surface temperature.
- To calculate LST statistics and area statistics from Google Earth Engine console outputs.
- To prepare a complete final report with output maps, calculations, interpretation, conclusion, future scope, and references.

Data Used

The analysis used Landsat Collection 2 Level 2 data in Google Earth Engine. Landsat 8 images were used for 2014, and Landsat 8/9 images were used for 2024. The time period was kept as March 1 to May 31 for both years to compare summer-season land surface temperature.

Item	Details
Before period	2014-03-01 to 2014-05-31
After period	2024-03-01 to 2024-05-31
Dataset	Landsat 8/9 Collection 2 Level 2
Platform	Google Earth Engine
Before Landsat 8 image count	6
After Landsat 8 image count	5
After Landsat 9 image count	6
Spatial scale	30 m for statistics and area calculation

Methodology

Step	Process
1. AOI preparation	Chennai focus boundary was selected and clipped to land-only pixels.
2. Image filtering	Landsat images were filtered by date, location, and cloud conditions.
3. Cloud masking	QA_PIXEL band was used to remove cloud and cloud-shadow pixels.
4. Composite creation	Median composites were generated for 2014 and 2024 to reduce noise.
5. Index calculation	NDVI, NDBI, NDWI, and LST were calculated.
6. UHI zoning	LST percentile thresholds were used to classify four heat zones.
7. Change detection	2024 LST was subtracted from 2014 LST to prepare the change map.
8. Statistics	Area and mean temperature values were calculated using pixel area and reduceRegion functions.

Formula Used

Formula	Expression	Purpose
NDVI	NDVI = (NIR - Red) / (NIR + Red)	Vegetation identification
NDBI	NDBI = (SWIR - NIR) / (SWIR + NIR)	Built-up extraction
NDWI	NDWI = (Green - NIR) / (Green + NIR)	Water-body extraction
LST in °C	LST = (ST_B10 × 0.00341802 + 149.0) - 273.15	Land surface temperature
LST Change	LST Change = LST2024 - LST2014	Temperature change
Area	Area sq.km = Σ(pixel area) / 1,000,000	Class-wise area
Percentage Change	Change % = ((New - Old) / Old) × 100	Relative change

Heat-zone classification was done using percentile thresholds: below P25 = Low Heat Zone, P25 to P50 = Moderate Heat Zone, P50 to P75 = High Heat Zone, and greater than or equal to P75 = Very High Heat Zone.

Results and Discussion

The main map outputs must be placed in this section because this is where the visual results are interpreted. The study area boundary belongs in the Study Area section, while LST maps, UHI zone maps, and the LST change map belong under Results and Discussion before the numerical tables.

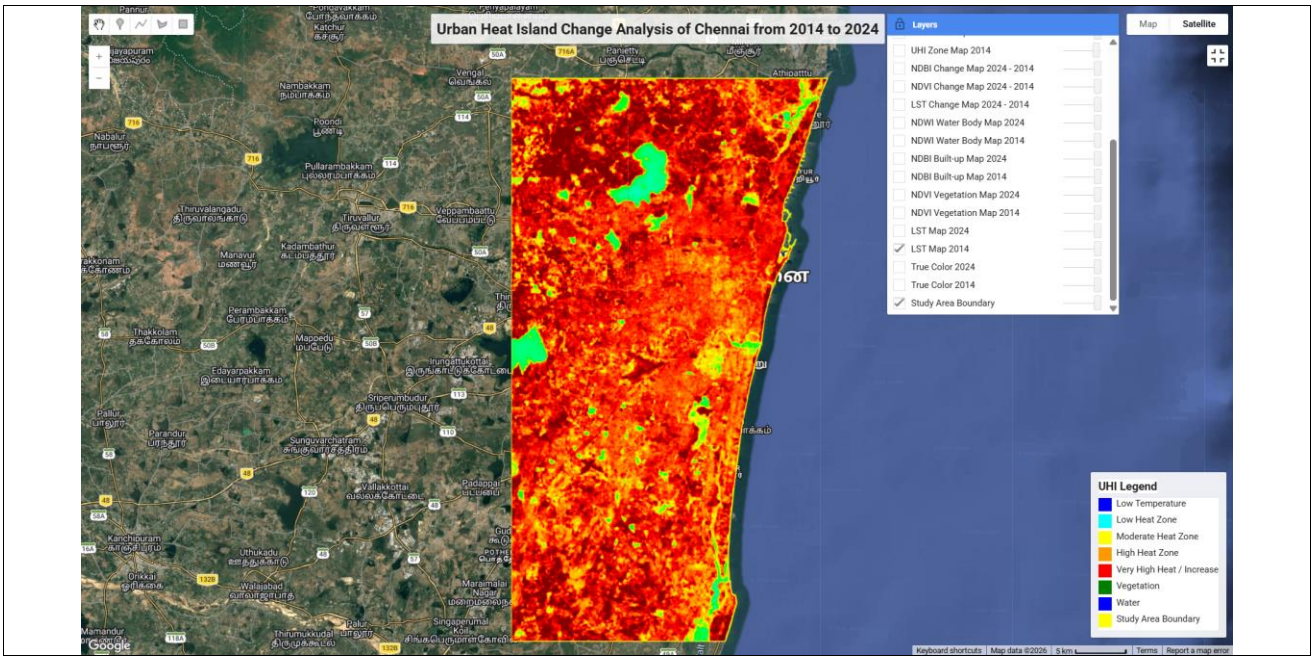


Figure 2. Land Surface Temperature Map 2014

This figure shows the surface temperature distribution during the 2014 summer-season composite. Higher-temperature pixels indicate built-up and exposed land surfaces, while comparatively cooler pixels are associated with vegetation and water influence.

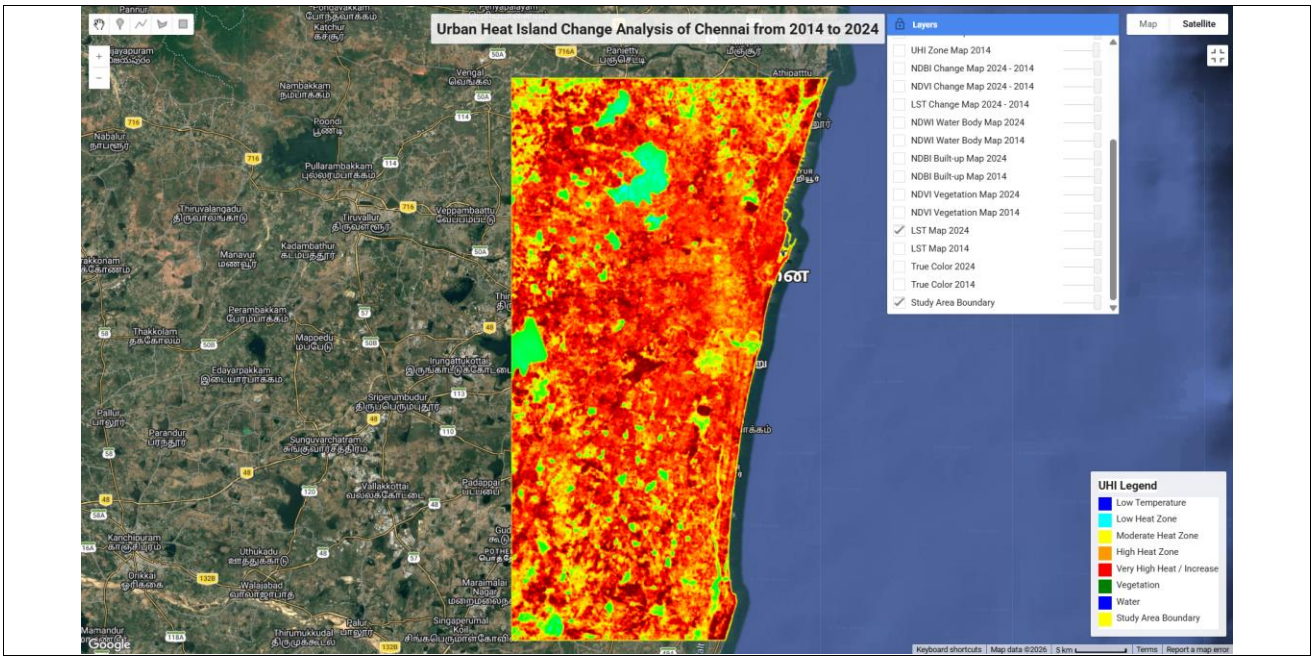


Figure 3. Land Surface Temperature Map 2024

This figure shows the surface temperature distribution during the 2024 summer-season composite. It is compared with the 2014 LST map to identify whether the overall thermal condition increased or decreased.

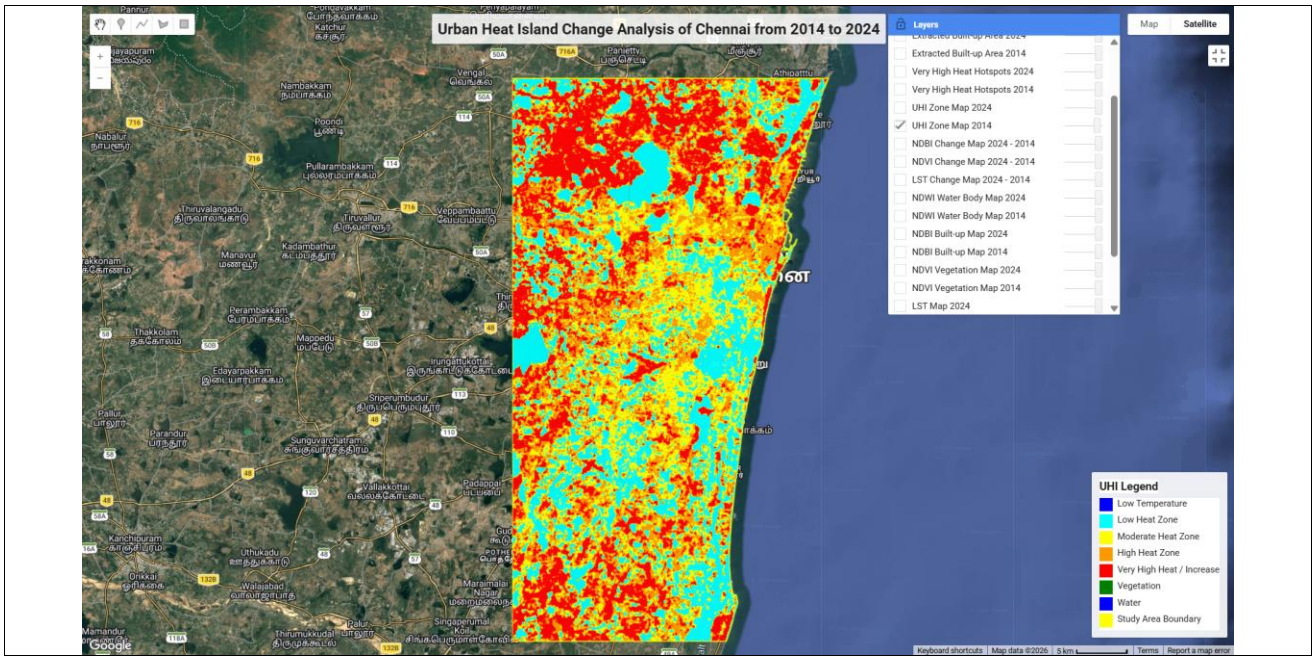


Figure 4. Urban Heat Island Zone Map 2014

This figure classifies the 2014 LST values into Low, Moderate, High, and Very High heat zones. It helps identify the 2014 hotspot pattern in the Chennai focus region.

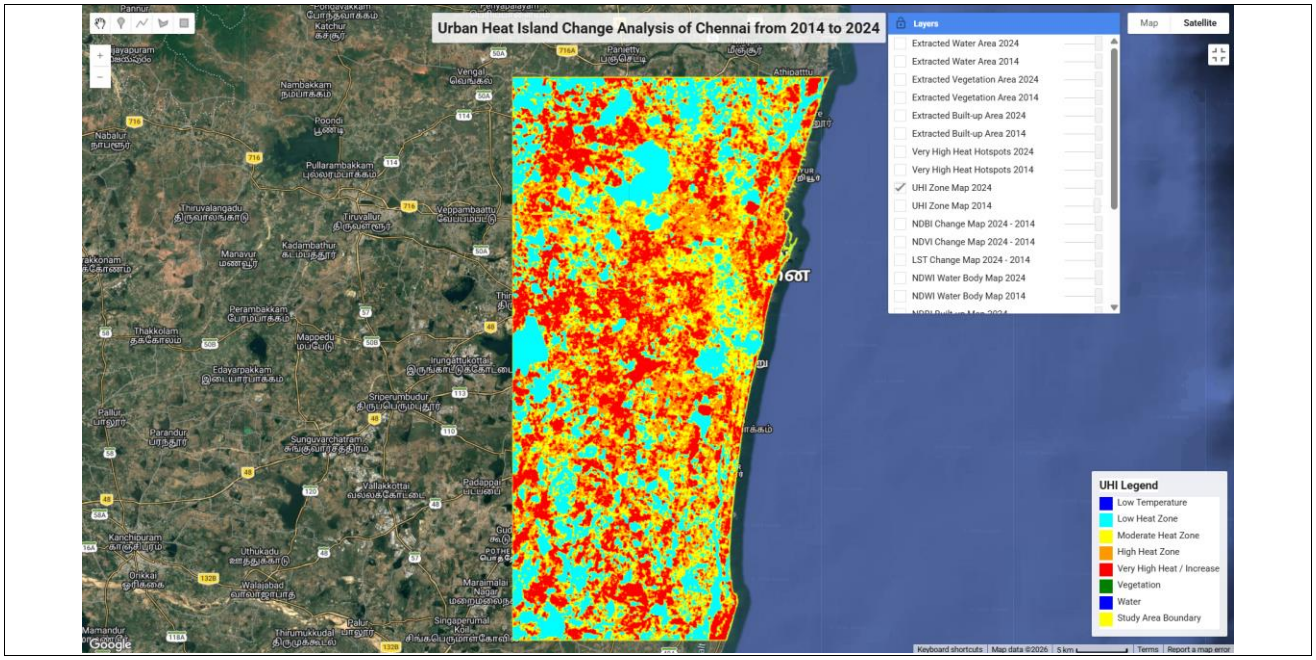


Figure 5. Urban Heat Island Zone Map 2024

This figure classifies the 2024 LST values into heat zones. Comparison with the 2014 heat-zone map shows the spatial change in urban heat intensity.

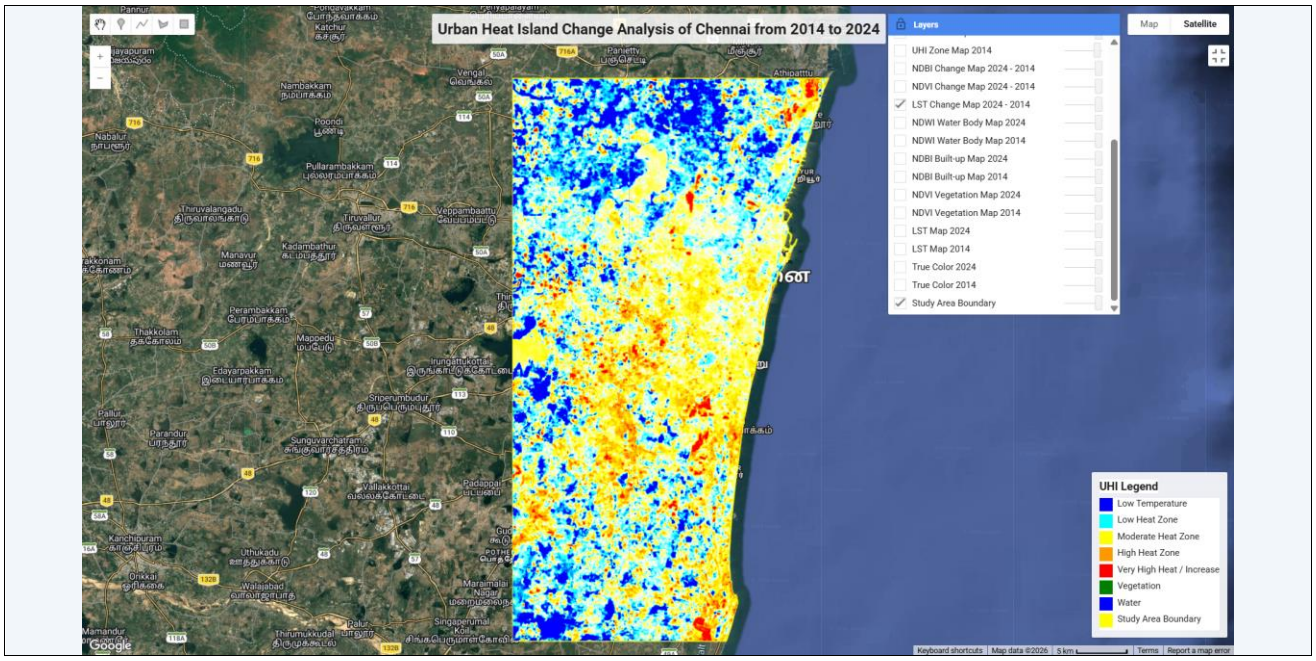


Figure 6. Land Surface Temperature Change Map 2014 to 2024

This is the most important change-detection output. Positive values show areas where temperature increased from 2014 to 2024, while negative values show areas where temperature decreased.

Numerical LST Results

The console statistics indicate that the mean land surface temperature decreased from 40.78 °C in 2014 to 39.55 °C in 2024. The calculated change is -1.23 °C. This result is for the selected March-May seasonal composites and should not be treated as a full-year average.

Statistic	2014 (°C)	2024 (°C)	Change
Minimum LST	28.17	27.00	-1.17
Mean LST	40.78	39.55	-1.23
Maximum LST	53.03	51.82	-1.21

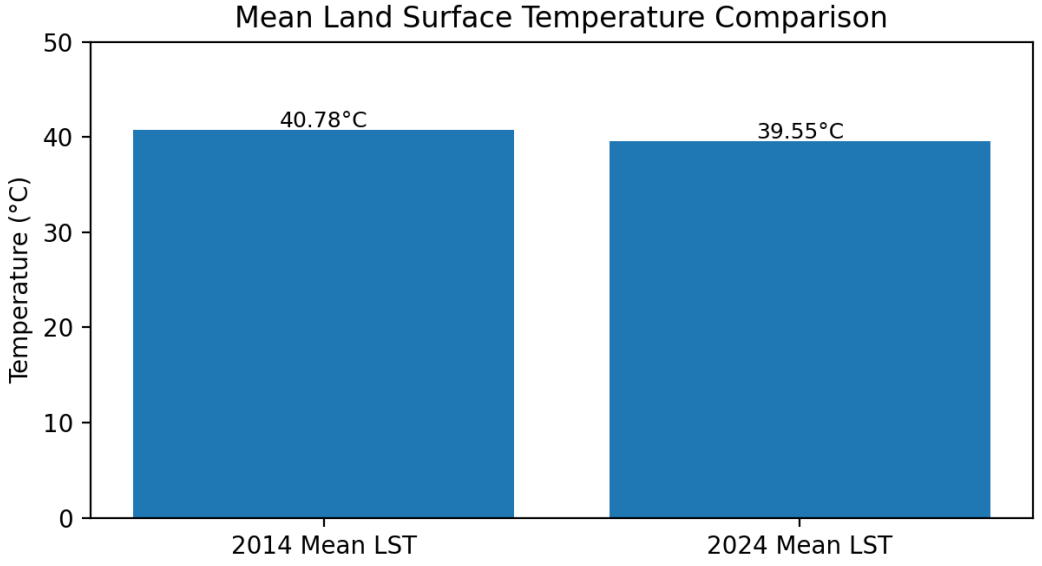


Figure 7. Mean LST comparison between 2014 and 2024.

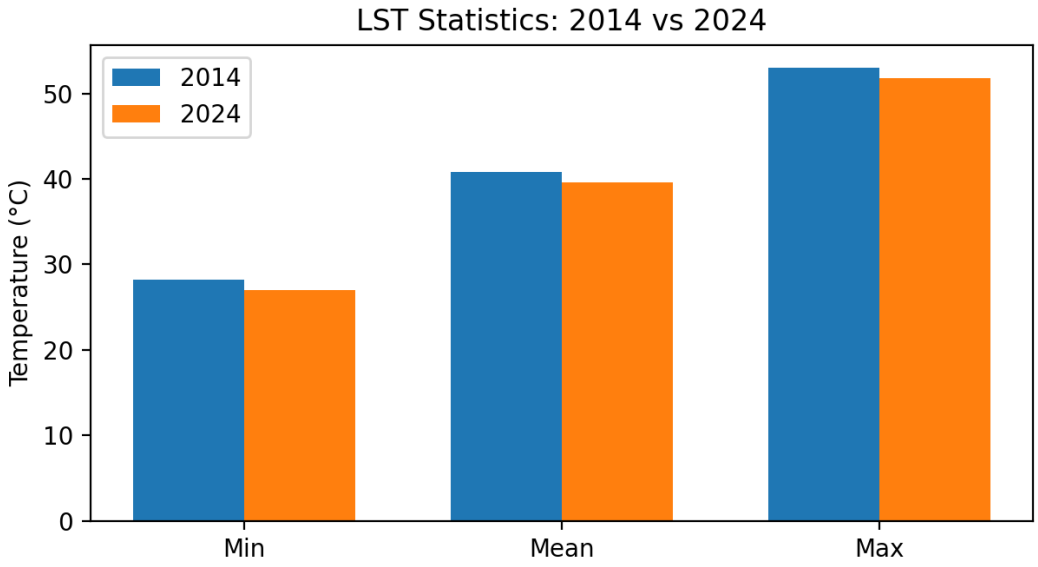


Figure 8. Minimum, mean, and maximum LST comparison.

Calculation: Mean LST Change = 2024 Mean LST - 2014 Mean LST = 39.5514 - 40.7769 = -1.2255 ℃, which is approximately -1.23 ℃.

Area Statistics

The following table contains the exact values that were readable from the uploaded console screenshots. Values that were not clearly readable were not guessed.

Class / Feature	Year	Area (sq.km)	Source
Low Heat Zone	2014	346.64	Console Screenshot 2
Very High Heat Zone	2024	350.06	Console Screenshot 2
Built-up Area	2014	847.60	Console Screenshot 3
Vegetation Area	2024	873.23	Console Screenshot 3

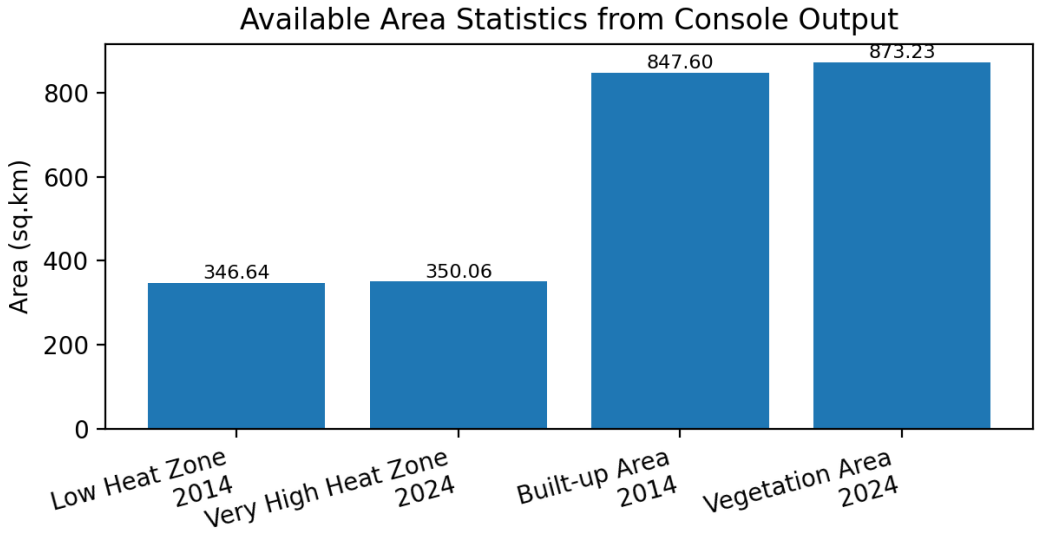


Figure 9. Available area statistics from console output.

Land-cover type	Year	Mean LST (°C)	Source
Built-up Area	2014	42.21	Console Screenshot 5
Vegetation Area	2024	39.36	Console Screenshot 5

The 2014 built-up mean LST value of 42.21 ℃ is higher than the overall 2014 mean LST, showing that built-up surfaces are important contributors to urban heating. The 2024 vegetation mean LST value of 39.36 ℃ supports the cooling role of vegetation-covered surfaces.

Main Findings

- Mean LST decreased by approximately 1.23 ℃ from 2014 to 2024 for the selected March-May periods.
- Maximum LST decreased by approximately 1.21 ℃, from 53.03 ℃ to 51.82 ℃.
- The available 2014 built-up area value is 847.60 sq.km.
- The available 2024 vegetation area value is 873.23 sq.km.
- Built-up area showed higher thermal influence, with 2014 built-up mean LST of 42.21 ℃.
- Vegetation showed cooling influence, with 2024 vegetation mean LST of 39.36 ℃.
- The LST change map is the key output for identifying spatial increase and decrease in temperature.

Conclusion

The Urban Heat Island Change Analysis of Chennai from 2014 to 2024 was completed using Landsat 8/9 Collection 2 Level 2 data in Google Earth Engine. The study generated LST maps, UHI zone maps, LST change map, vegetation and built-up indicators, and numerical statistics. The main result shows that mean LST decreased by about 1.23 ℃ for the selected summer-season composites. Even with this mean decrease, built-up surfaces continue to show stronger heat influence than vegetation-covered areas. The study confirms that remote sensing and Google Earth Engine are effective for monitoring UHI patterns and supporting urban environmental analysis.

Future Scope

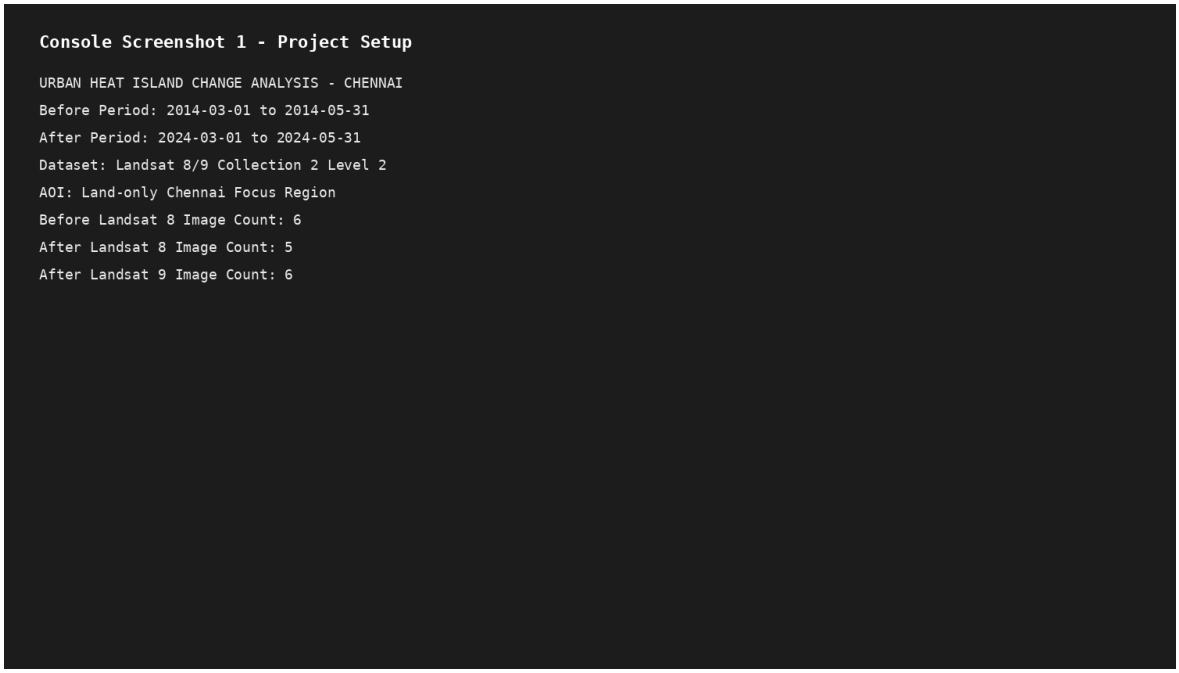
- Use the full official Chennai district boundary and compare it with metropolitan expansion regions.
- Include multiple years such as 2016, 2018, 2020, 2022, and 2026 to build a long-term UHI trend.
- Validate Landsat-derived LST using ground weather-station data.
- Perform ward-wise or zone-wise hotspot analysis for better planning decisions.
- Combine Sentinel-2 land-cover mapping with Landsat thermal data for improved spatial detail.
- Suggest mitigation measures such as urban greening, cool roofs, water-body restoration, and reduction of impervious surfaces.

References

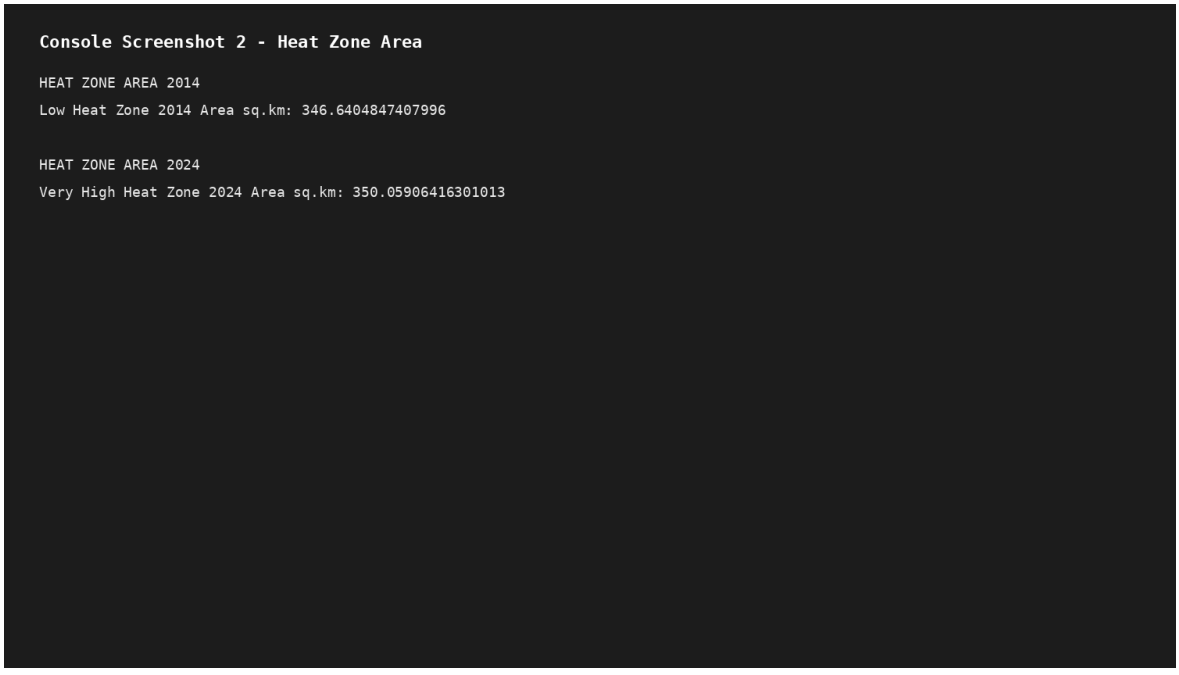
1. Google Earth Engine Data Catalog.
2. Landsat 8/9 Collection 2 Level 2 Dataset.
3. USGS Landsat Mission.
4. Urban Heat Island remote sensing studies.

Appendix: Console Screenshot Evidence

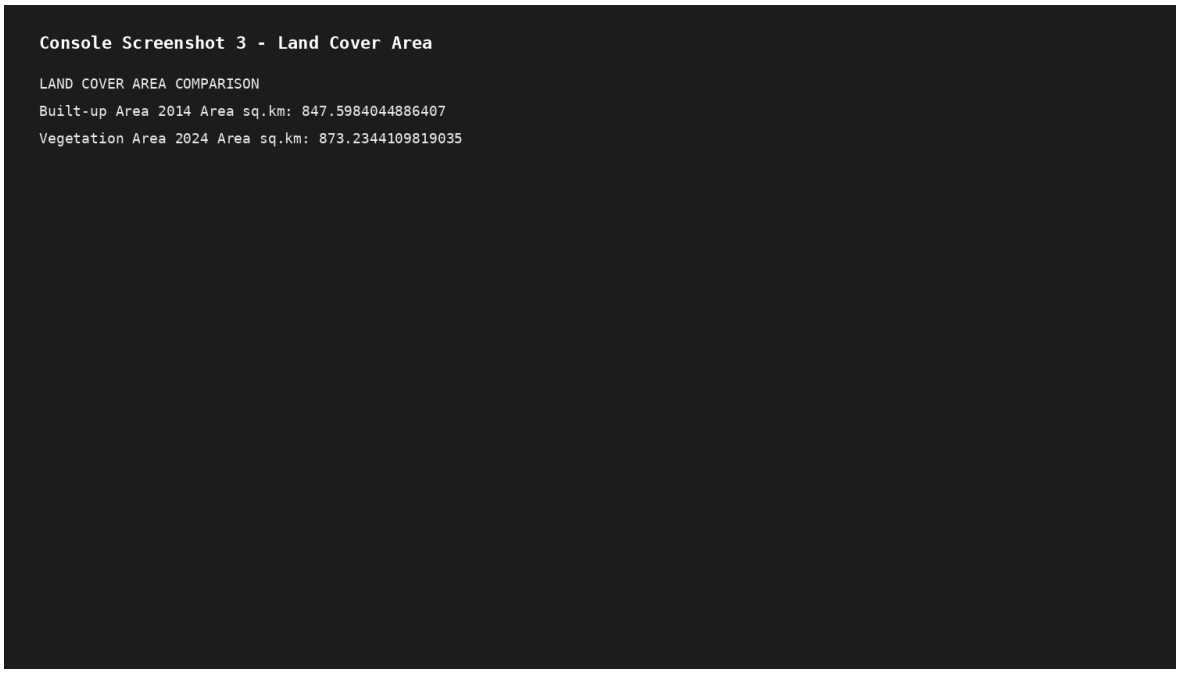
The following console evidence panels are reconstructed from the readable console screenshot text and are included to show the values used for calculation.



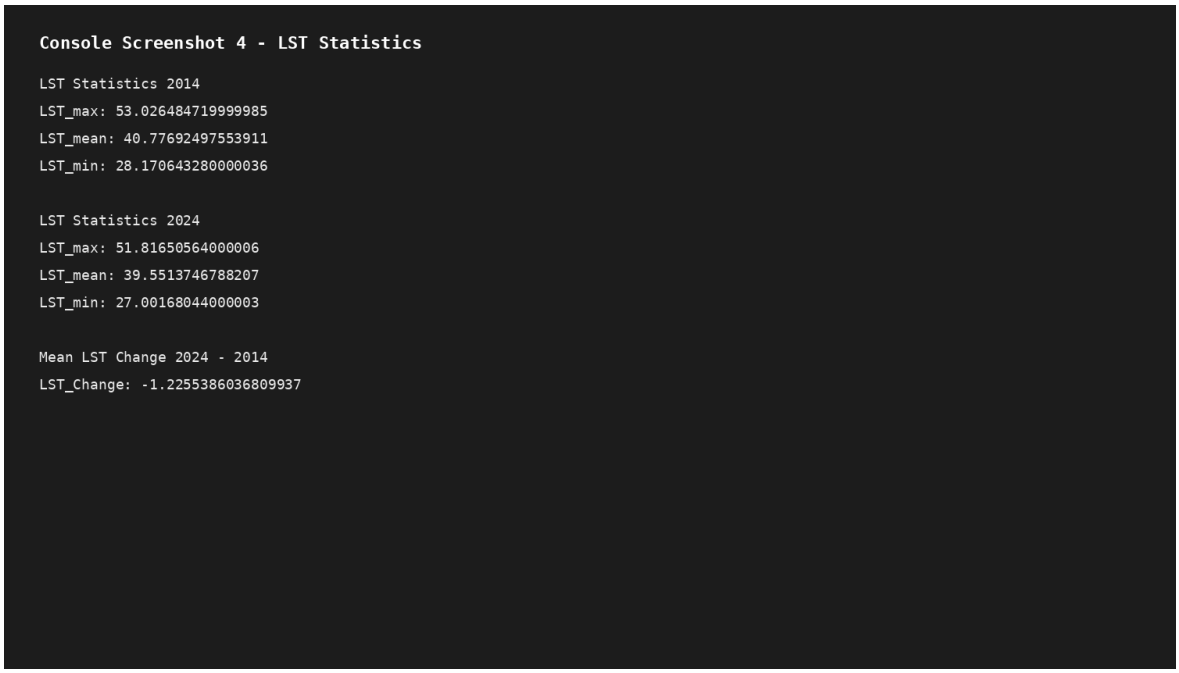
Appendix Figure A1. Console Screenshot 1 evidence panel.



Appendix Figure A2. Console Screenshot 2 evidence panel.



Appendix Figure A3. Console Screenshot 3 evidence panel.



Appendix Figure A4. Console Screenshot 4 evidence panel.

Appendix Figure A5. Console Screenshot 5 evidence panel.