Urban Heat Island Detection in Porto

A Geospatial and Remote Sensing Analysis using Landsat Data and Python
2025, Porto

Abstract

This project maps and analyses Urban Heat Islands (UHIs) in the City of Porto using remote sensing and geospacial techniques.

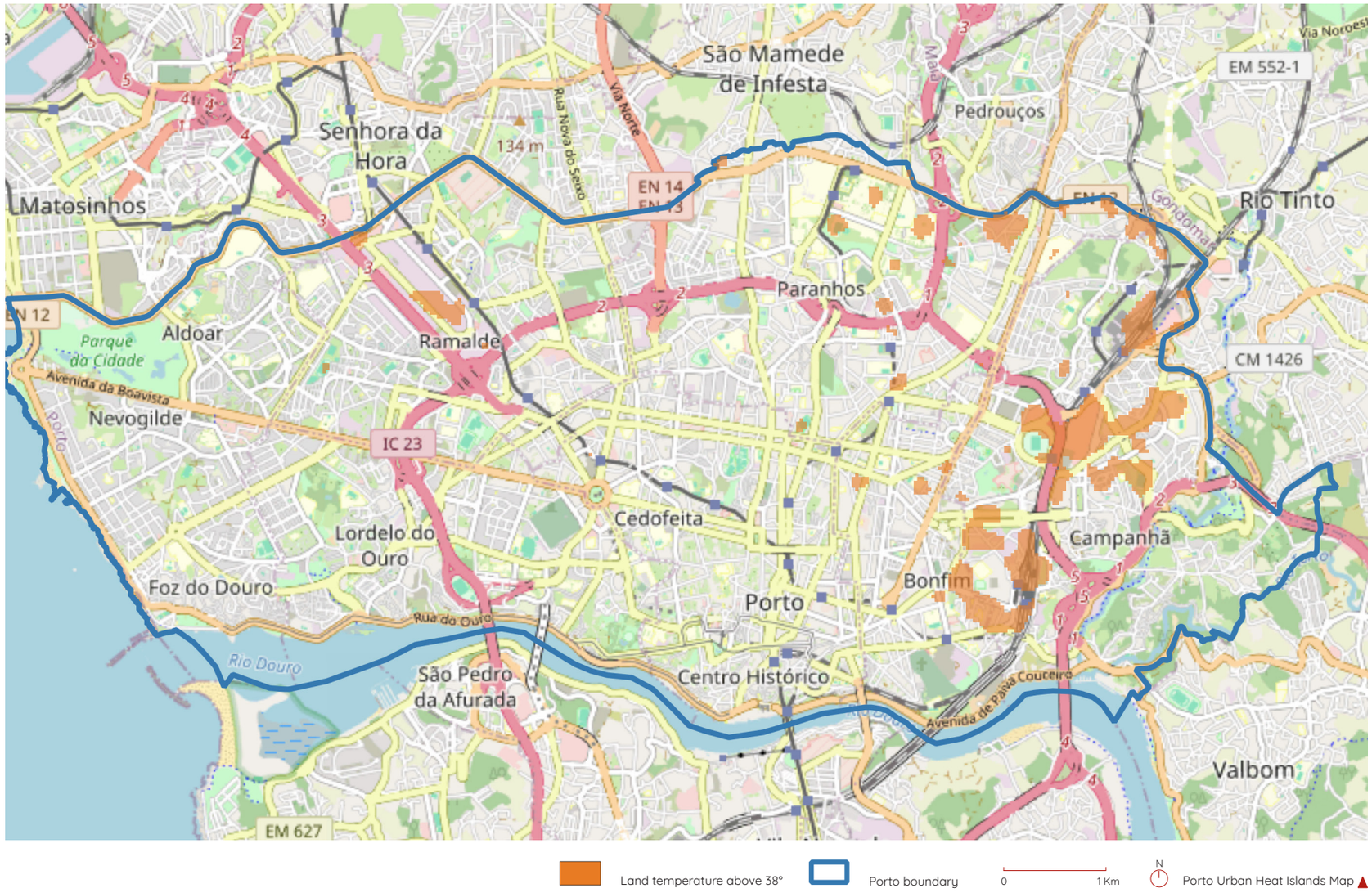
Using Landsat 8 thermal infrared images (Band 10) from 4 July 2024, a warm and cloudless summer day.

I calculated Land Surface Temperature (LTS) by converting raw satellite radiance data into brightness temperature in degrees Celsius. The raster was spacially clipped to the Porto administrative boundary, and LST values were classified into four heat zones.

The resulting thermal map reveals spacial disparities in surface temperature distribution across the urban area, with critical zones concentrated in specific areas of the city - namely, in the East, in Freguesia de Campanhã.

All processing was performed in Python using rasterio, geopandas and matplotlib, and visualised in QGIS.

The final output was a classified heat stress raster that will enable further spacial analysis and the adoption of the right measures to mitigate this effect of climate change.



Objectives

- Detect and visualise temperature extremes in Porto.
- Identify critical zones for urban heat.
- Classify land surface temperature into categories.
- Export results for QGIS for visualisation and future urban intervention.

Tools

- **Python:** for preprocessing and temperature mapping
- **Rasterio**: for reading and masking GeoTIFF sattelite bands
- **Matplotlib:** for visualising data
- **QGIS:** map composition and geospacial visualisation
- **USGS Land Explorer:** source of Landsat thermal images
- **Landsat 8:** for manipulating shapefiles
- **GeoPandas:** for manipulating shapefiles

Methodology

Step 1: AI Guided Workflow Design

Project planned and developed through an iterative and collaborative process with ChatGPT-4o. The model assisted with decision-making, tool selection, code generation, error debugging and geospacial methodology design. Through this approach, I was able to learn the process while ensuring a sound technical foundation. All steps were reasoned and explained in real time, allowing me to understand and apply remote sensing workflows: explore and visualise data in QGIS and apply best practices in satellite data preprocessing and GIS export.

Step 2: Area Selection

Acquisition of boundary for Porto filtered from national shapefile.

Step 3: Data Collection

Landsat 8 (Band 10 - thermal infrared), 4 July 2024, from USGS EarthExplorer

Step 4: Preprocessing

Radiance was extracted from Band10 and converted into brightness temperature.

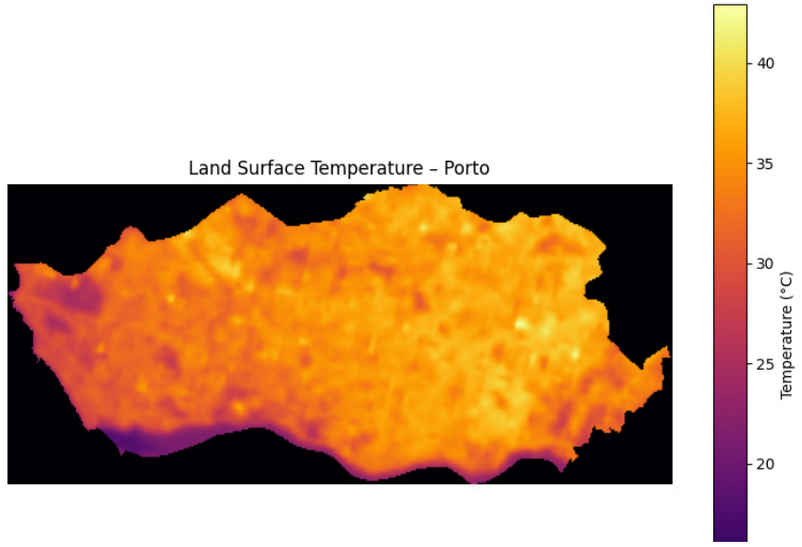
Step 5: Classification

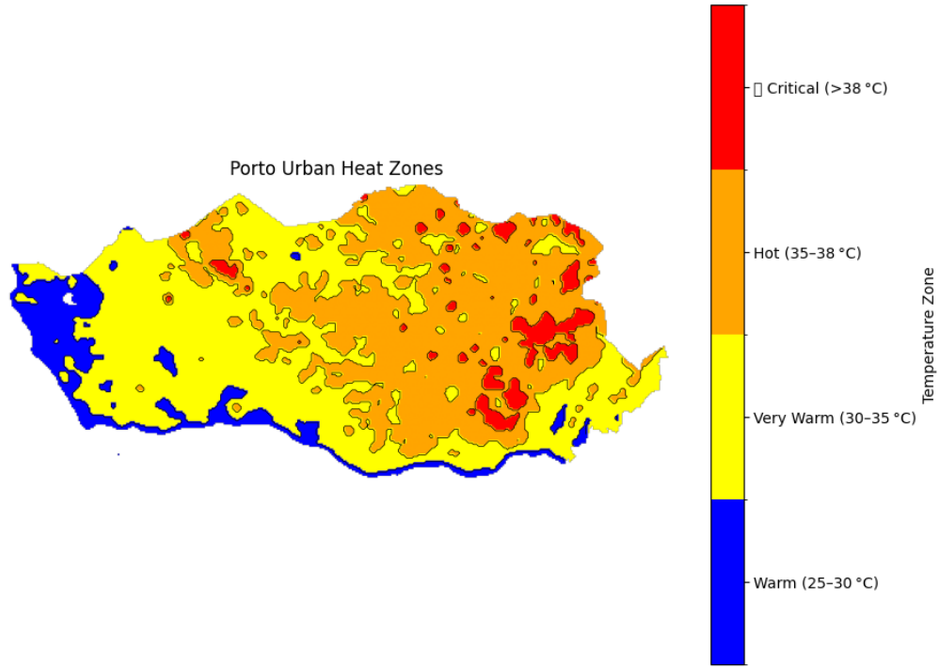
Temperature thresholds applied:

- Warm: 25 -30 degrees Celsius
- Very Warm: 30-35 degrees Celsius
- Hot: 35-38 degrees Celsius
- Critical: above 38 degrees Celsius

Step 6: Visualisation

Classified raster plotted using matplotlib and QGIS.





Results

Porto's heat islands were visualised and high density critical zones identified, with special emphasis on the East of the City:

- Estação de Campanhã and surrounding areas
- Surrounding areas of Estádio do Dragão, Mercado Abastecedor and Ilhéu.
- Estação de Contumil
- Some areas in Polo Universitário S. João
- and others.

Discussion

The rapid evolution of AI makes it easier for architects to have a deeper understanding of the urban environment, which can have a deep impact on their design proposals. Considering the rapid impact of climate change in our cities, it would be of paramount importance for architects to introduce these kind of analysis in the first stages of project. In this case, with publicly available data, a basic computer and intermediate programming knowledge, I could identify the Porto Heat Islands.

The results highlight the social disparity of the city and the need for interventions sensitive to this issue.

Future steps

This analysis can be taken further, using publicly available data to further advance our understanding of the problem and making us better equipped to provide an efficient and socially just solution for these areas. As an example, we could correlate the Normalized Difference Vegetation Index (a metric that measures the live vegetation in the area) and the heat islands, understanding the impact of vegetation in the problem.

Conclusion

The issue of climate change brought important consequences to our city, and the increase of heat islands is one such problem.

This project demonstrates how easily accessible tools and data can empower designers and planners to recognize invisible climate patterns. By integrating this kind of geospatial analysis into early stage design, we can better protect vulnerable communities and build urban resilience.