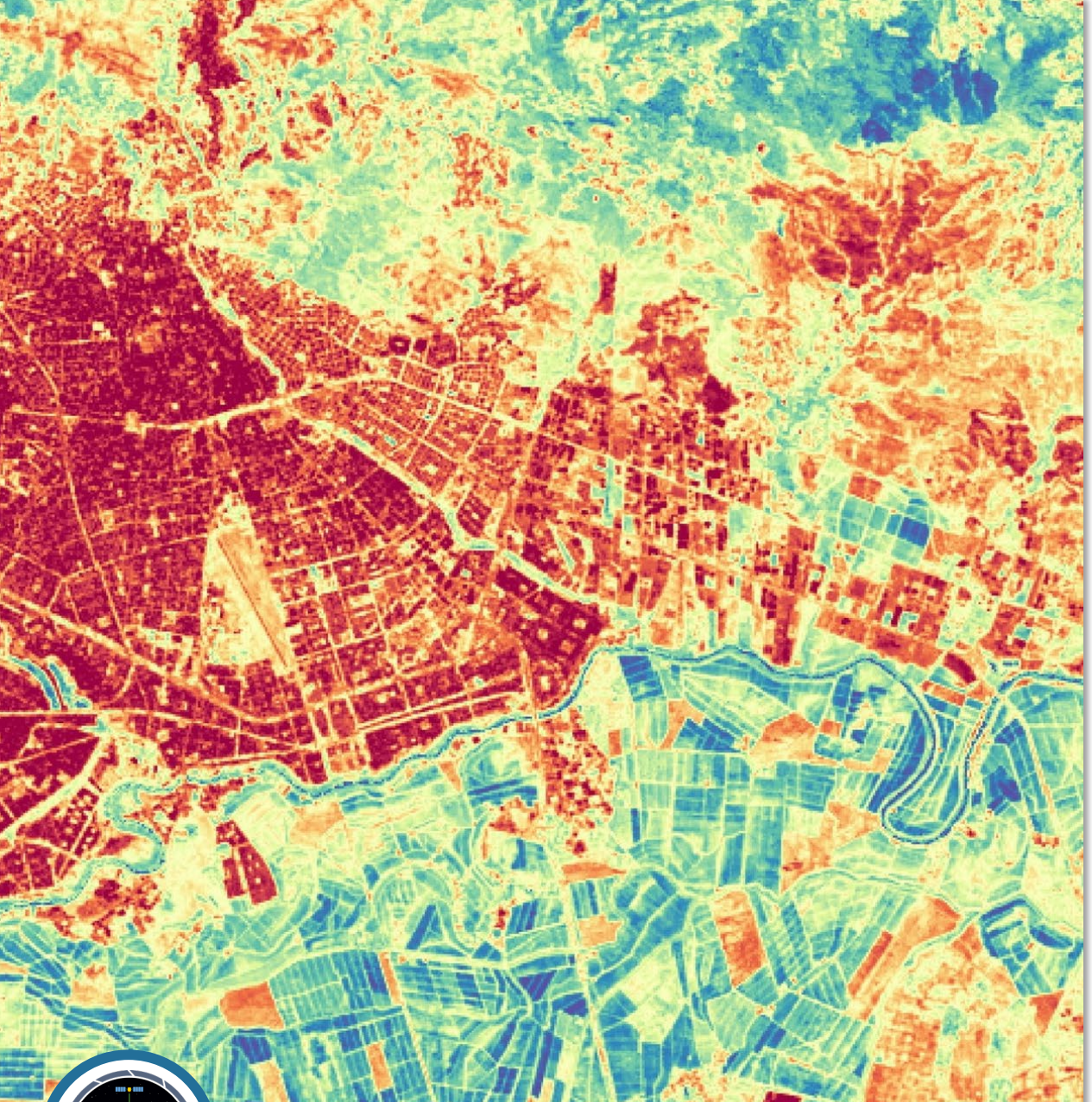


National Aeronautics and Space Administration

CALI URBAN DEVELOPMENT II

Investigating the Impacts of Land Use Change on Urban Heat and Social Vulnerability in Cali, Colombia

Gabi Davidson-Gomez

Brenna Bruffey

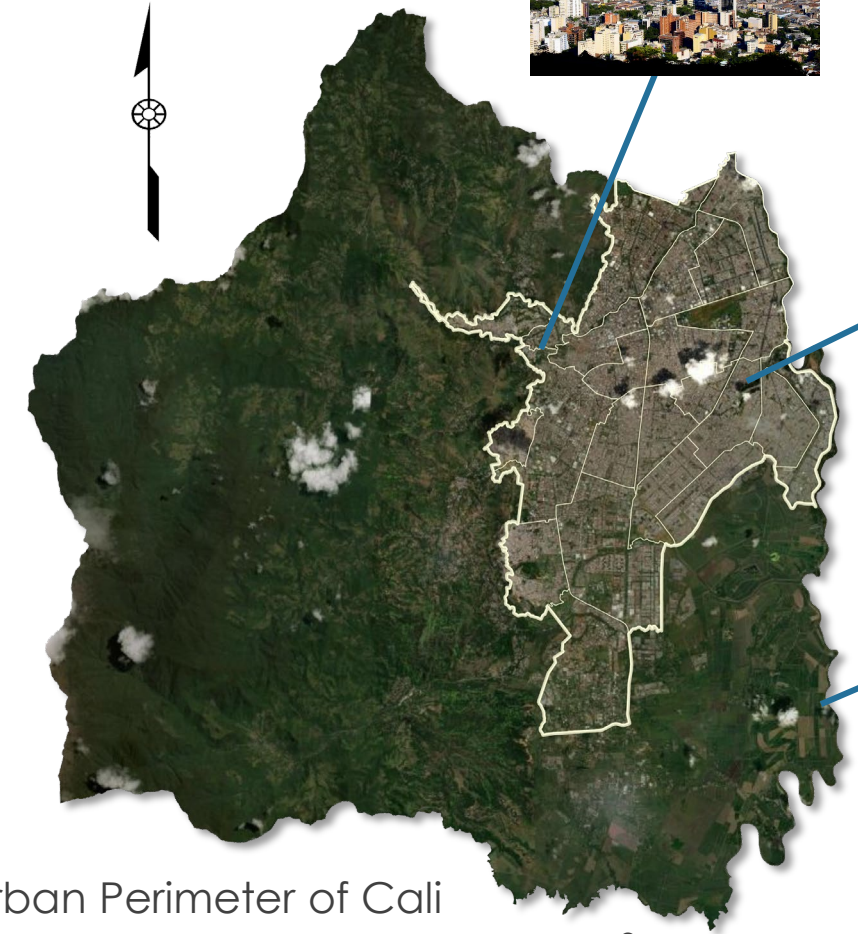
Deya Rodríguez

Isabelle Solórzano

DEVELOP

California – Ames | Summer 2024

STUDY AREA & PERIOD



Urban Perimeter of Cali

Cali within Colombia

Study Area

Cali, Colombia

Study Period

Start - January 1st, 2013

End - December 31st, 2023

Image Credit: Viviana Maria Sanchez Escobar, Worldwide Wandering

Service Layer Credits: Earthstar Geographics

PARTNERS

Image Credit: Viviana María Sánchez Escobar

Departamento Administrativo de Gestión del Medio Ambiente (DAGMA)

Fundación Dinamizadores Ambientales

COMMUNITY CONCERNS

Deforestation and wetland declination

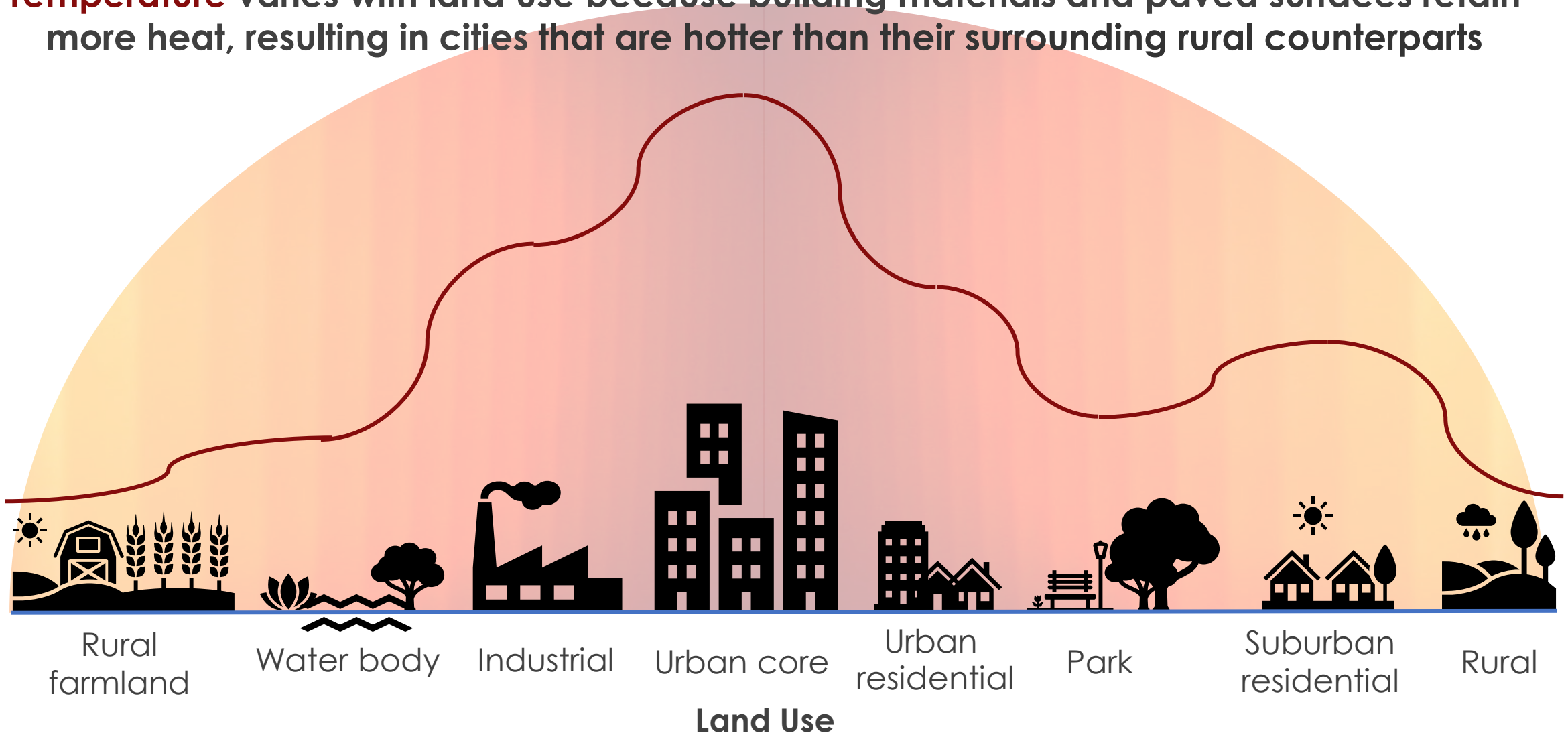
Rising temperatures, especially in urban zones

Heat exacerbated with social vulnerability

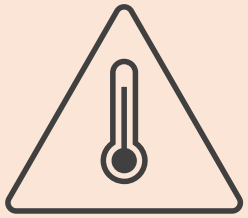
Determine locations for cooling interventions

URBAN HEAT ISLAND EFFECT

Temperature varies with land use because building materials and paved surfaces retain more heat, resulting in cities that are hotter than their surrounding rural counterparts

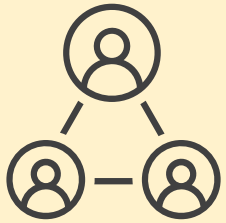


OBJECTIVES



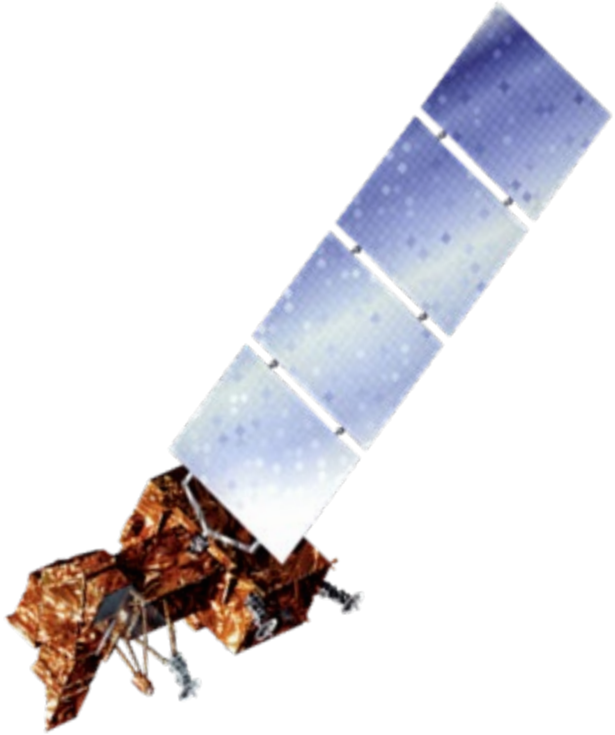
Identify **temperature hot spots** within the city

Generate **landcover maps** to determine land use patterns



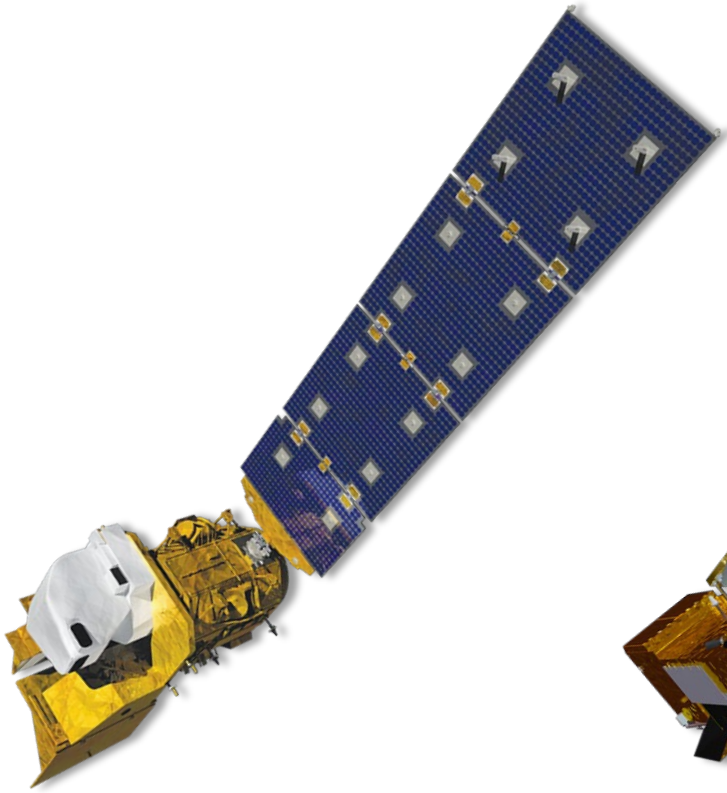
Compare the relationship between **land use, temperature, and social factors**

EARTH OBSERVATIONS

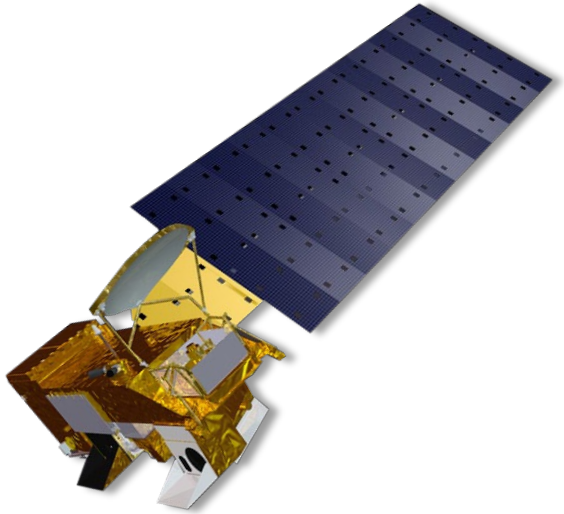


Landsat 7
ETM+

Landsat 8
OLI/TIRS



Landsat 9
OLI-2/TIRS-2



Aqua
MODIS

Image Credit: NASA

METHODOLOGY: Urban Heat

Acquisition

- UHEAT 2.0 Code
- Landsat 7, 8 and 9 Imagery
- MODIS Imagery

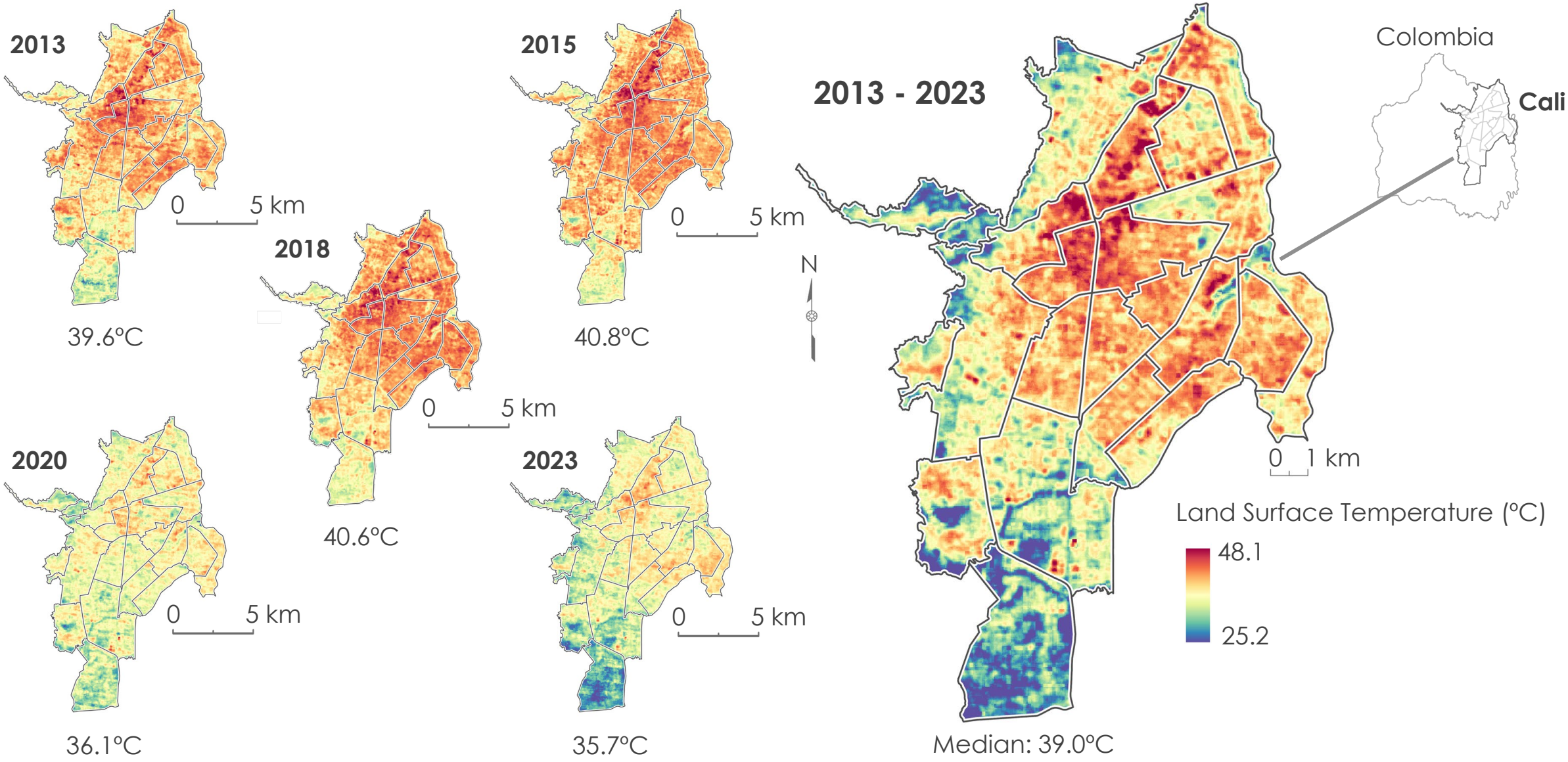
Processing

- Transformed Code from Python to GEE syntax
- Combine Image Collections in GEE
- Applied Cloud Mask in GEE

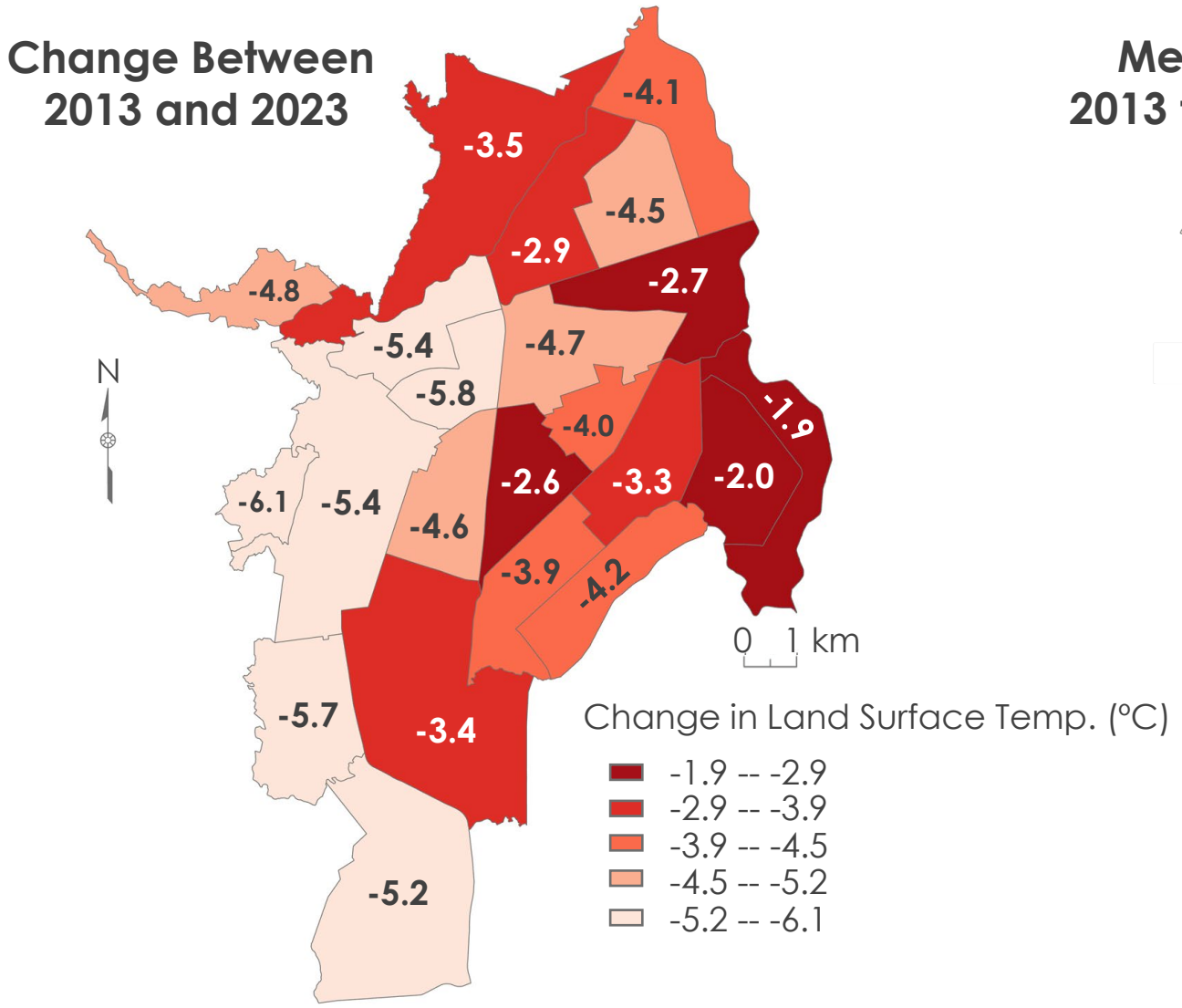
Analysis

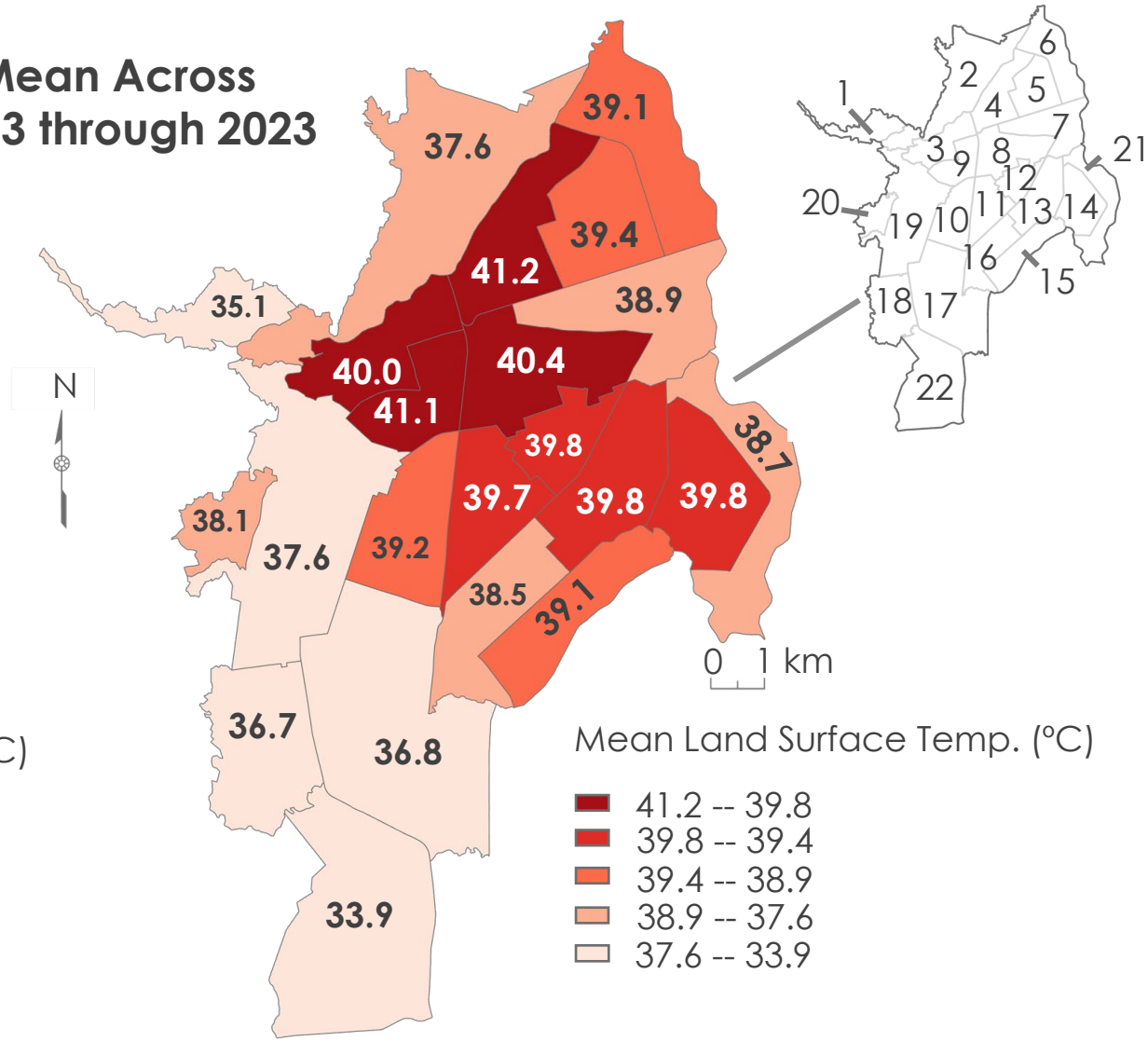
- Zonal Statistics by Comuna
- Validity Check Using MODIS and Temperature Quality Assessment

RESULTS: Urban Heat



RESULTS: Mean Urban Heat





METHODOLOGY: Land Use/Land Cover

Acquisition

Landsat 8 Imagery from USGS Earth Explorer

Processing

Applied Cloud Mask in ArcGIS Pro

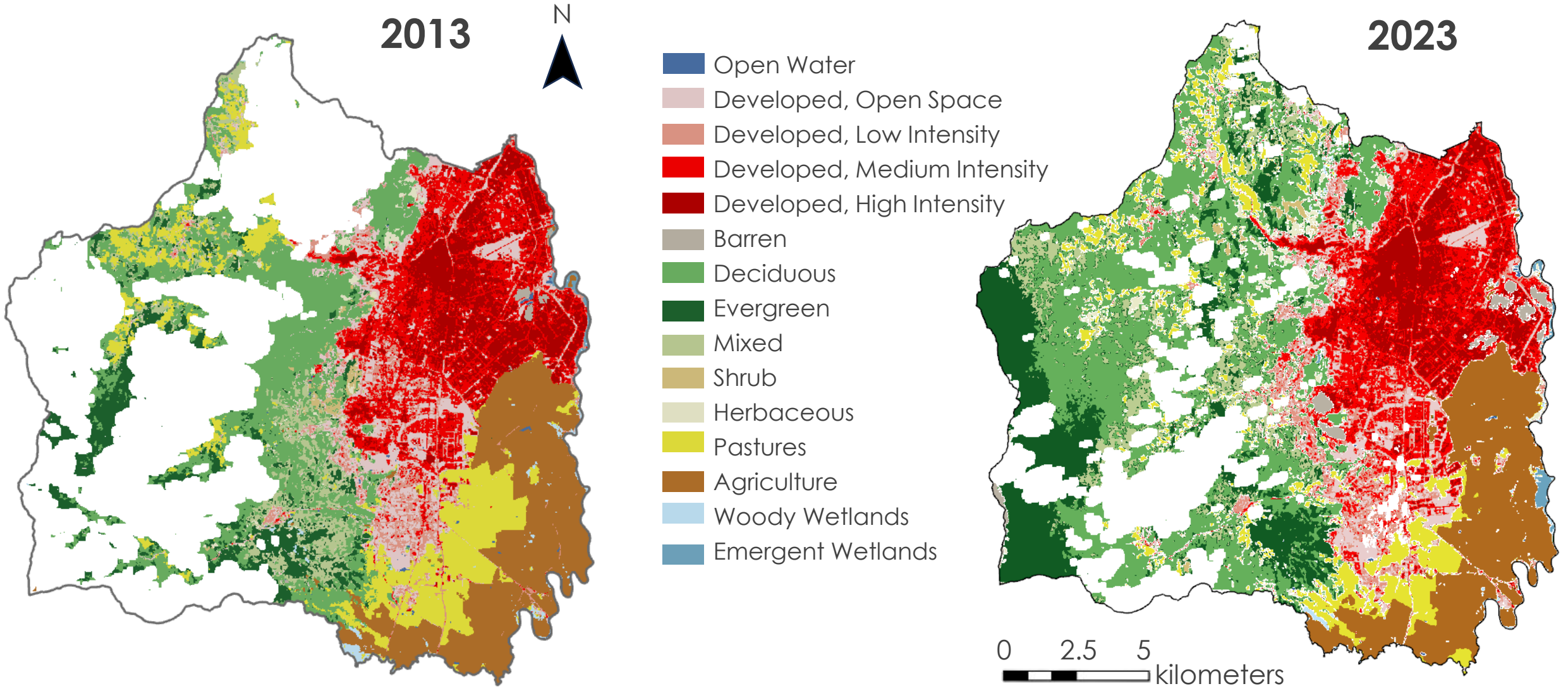
Deep Learning Land Classification Model

Analysis

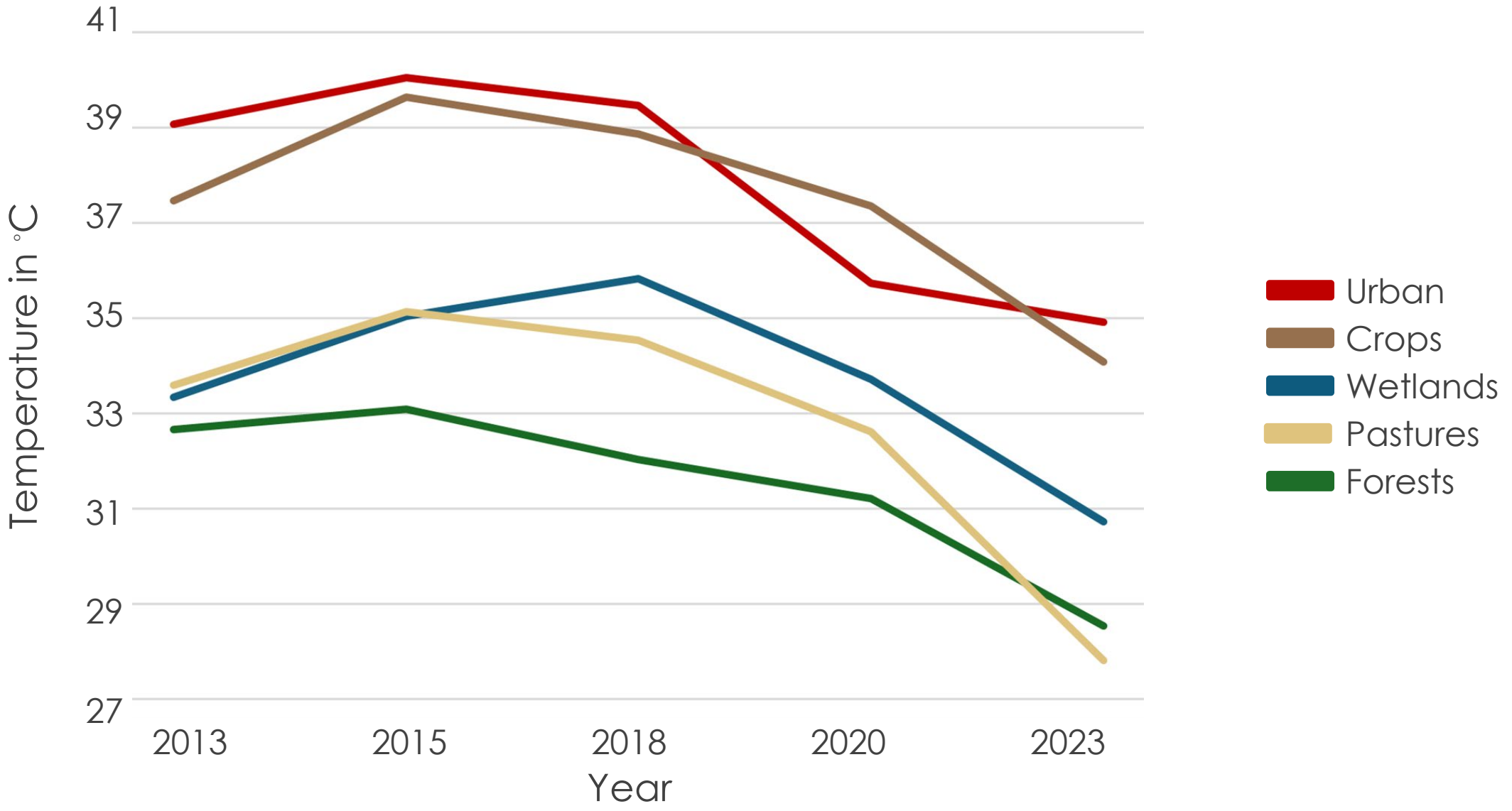
Zonal Statistics by Comuna

Change Detection Wizard for 5- and 10-year Periods

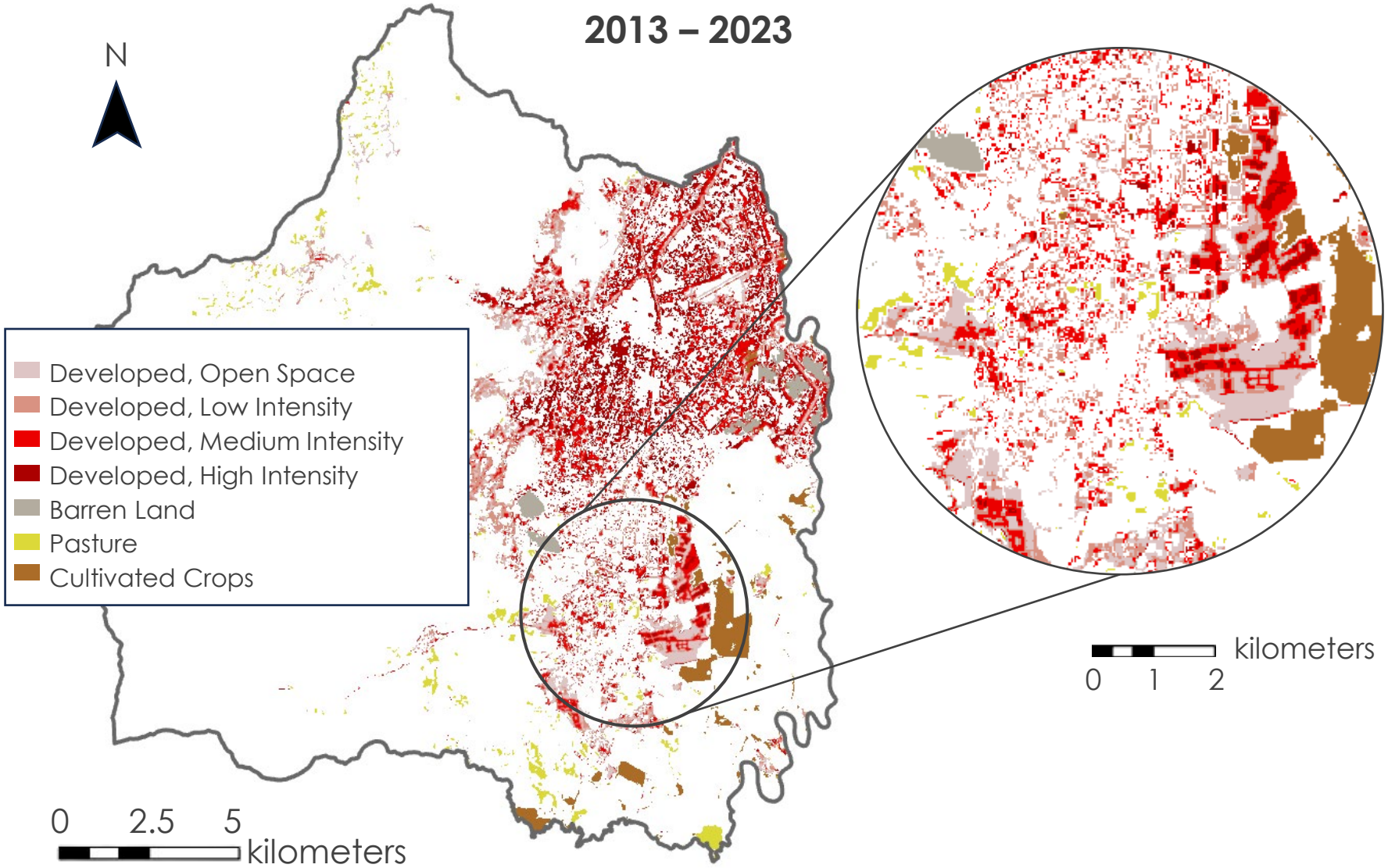
RESULTS: Land Cover



RESULTS: Urban Heat and Land Use

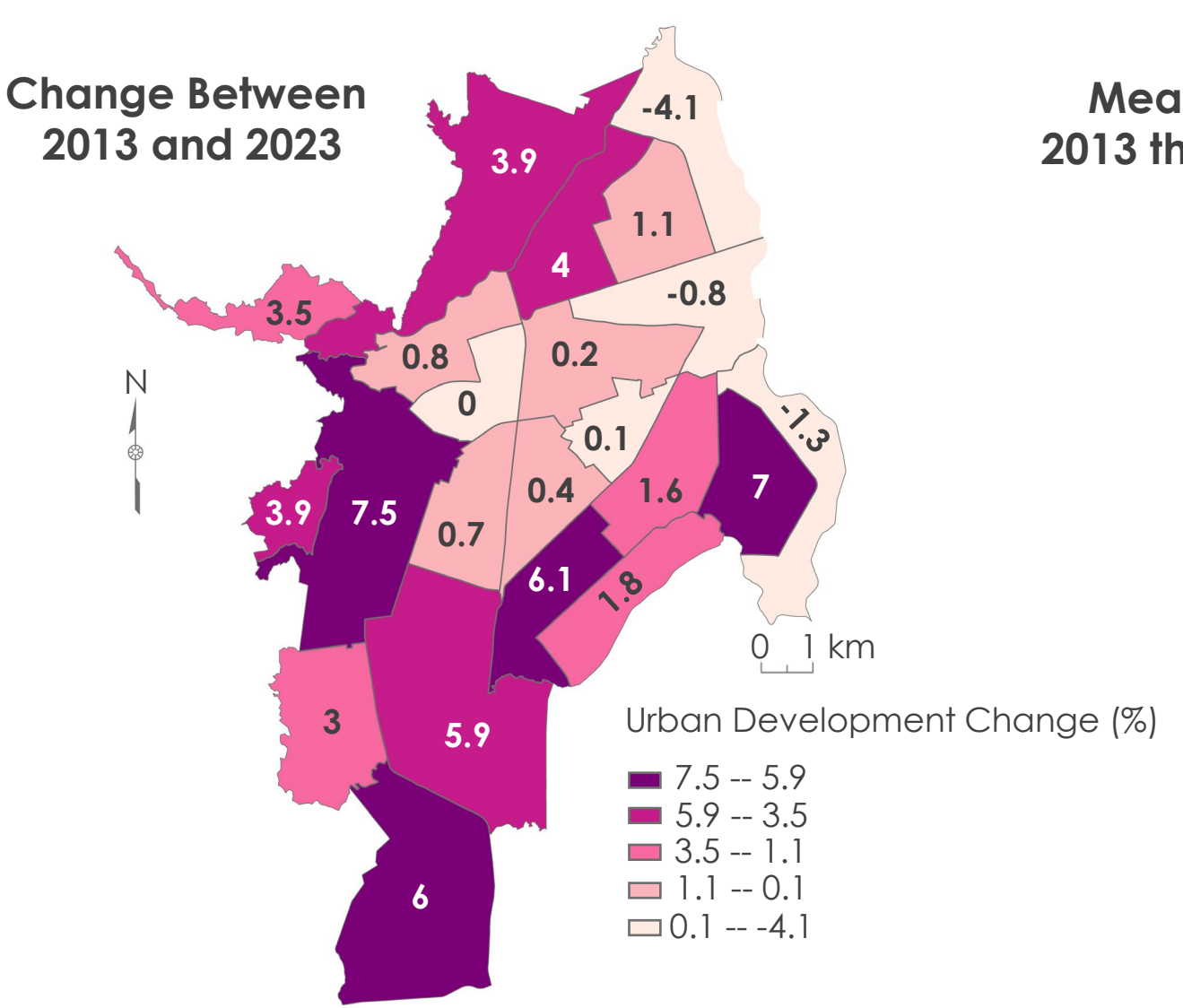


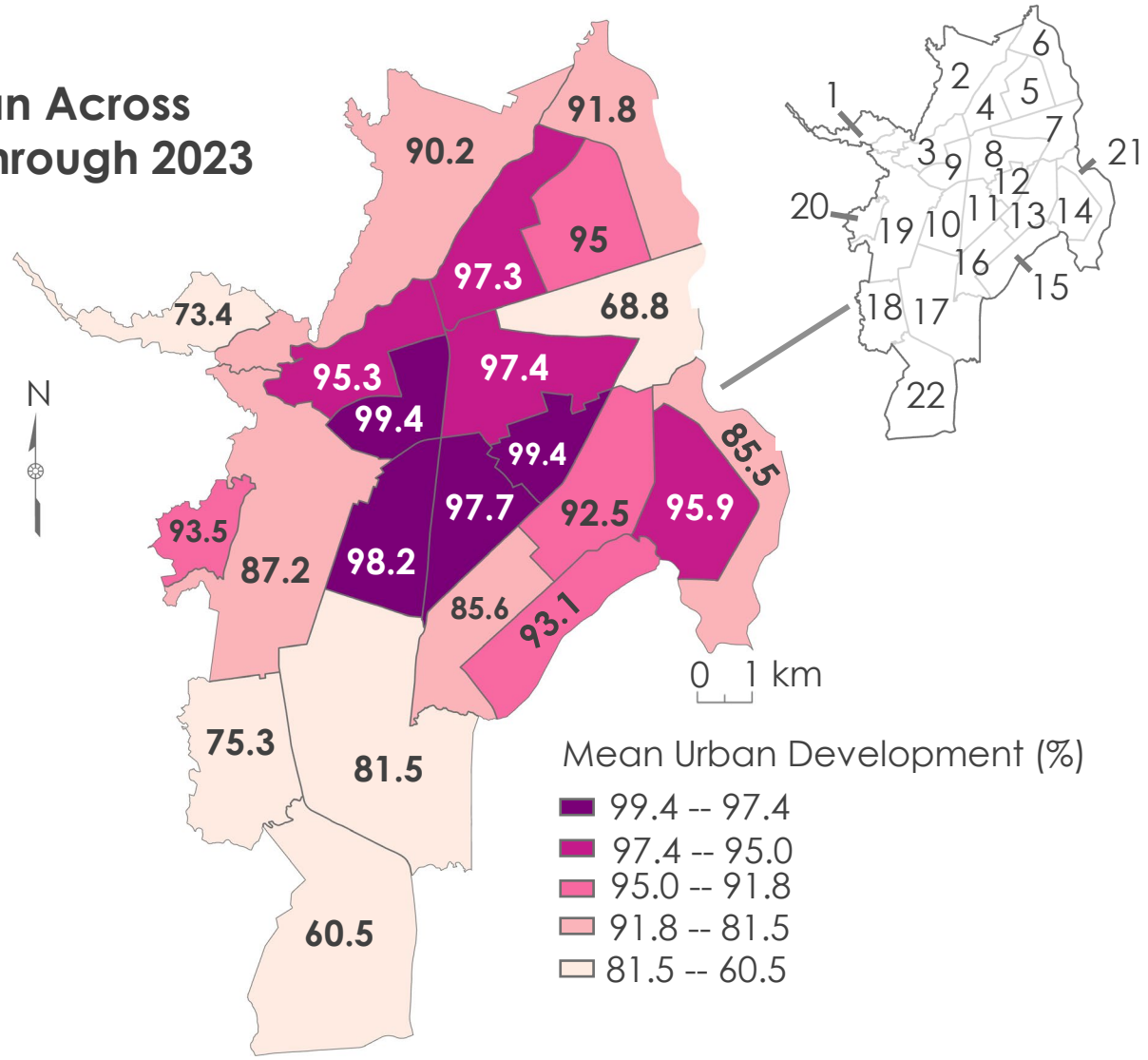
RESULTS: Land Cover Change



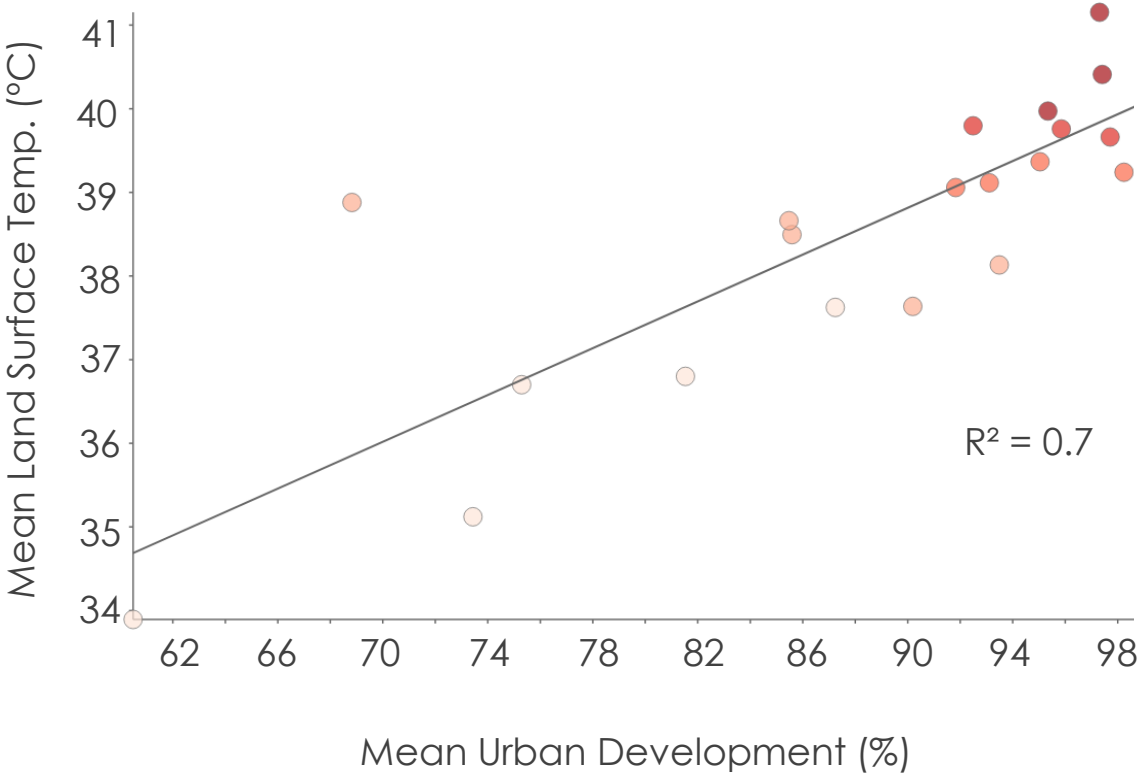
- **52.8 km²** experienced an increase in developed cover
- **8.4 km²** of deciduous forests were converted for human use

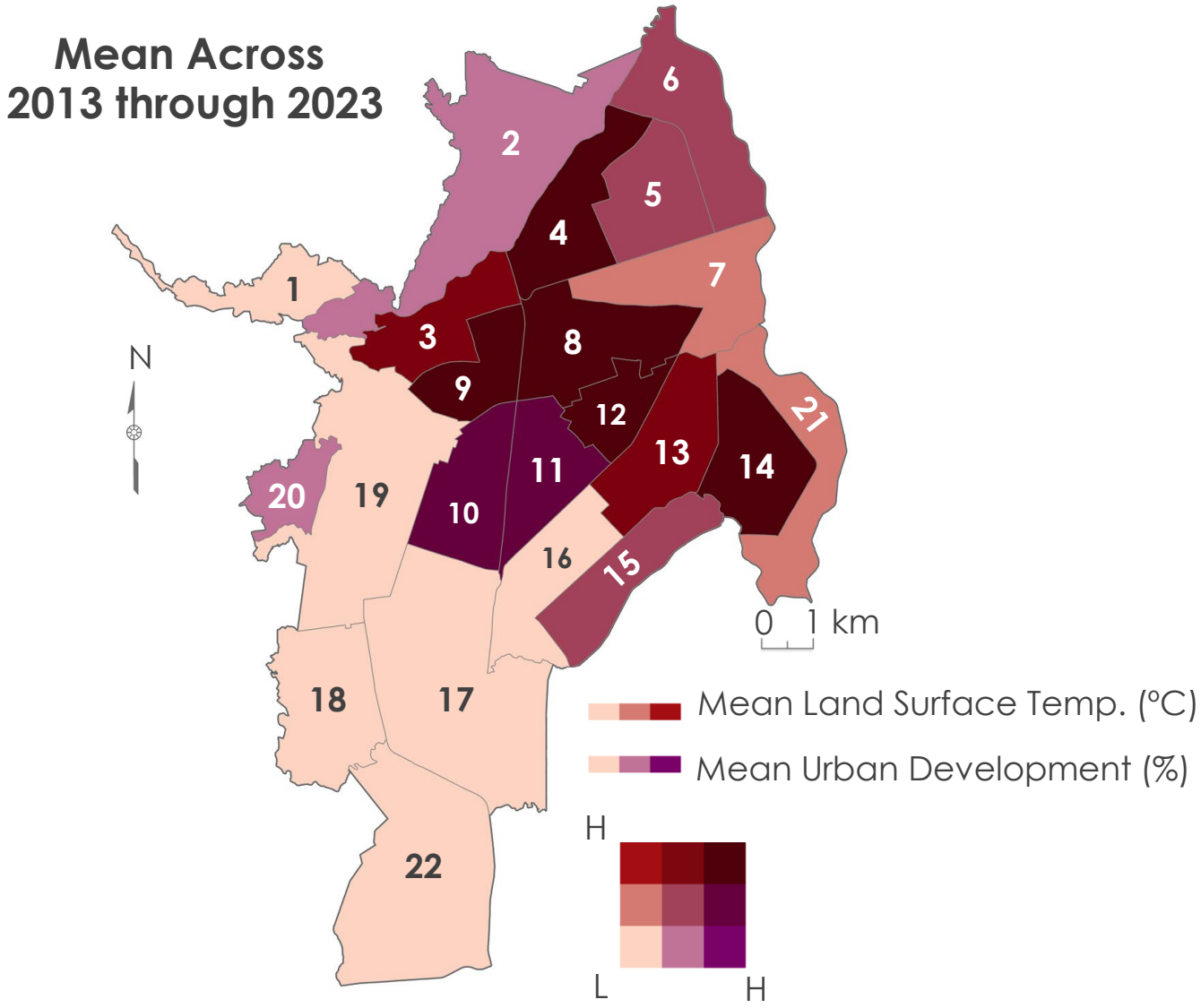
RESULTS: Urban Land Use Change





RESULTS: Urban Development vs Heat





METHODOLOGY: Social Vulnerability

Acquisition

Demographic Data From "Cali en Cifras" and Other Municipal Datasets

Processing

Converted Numerical Population Shares Data to Percentages

Calculated Green Space Access in QGIS

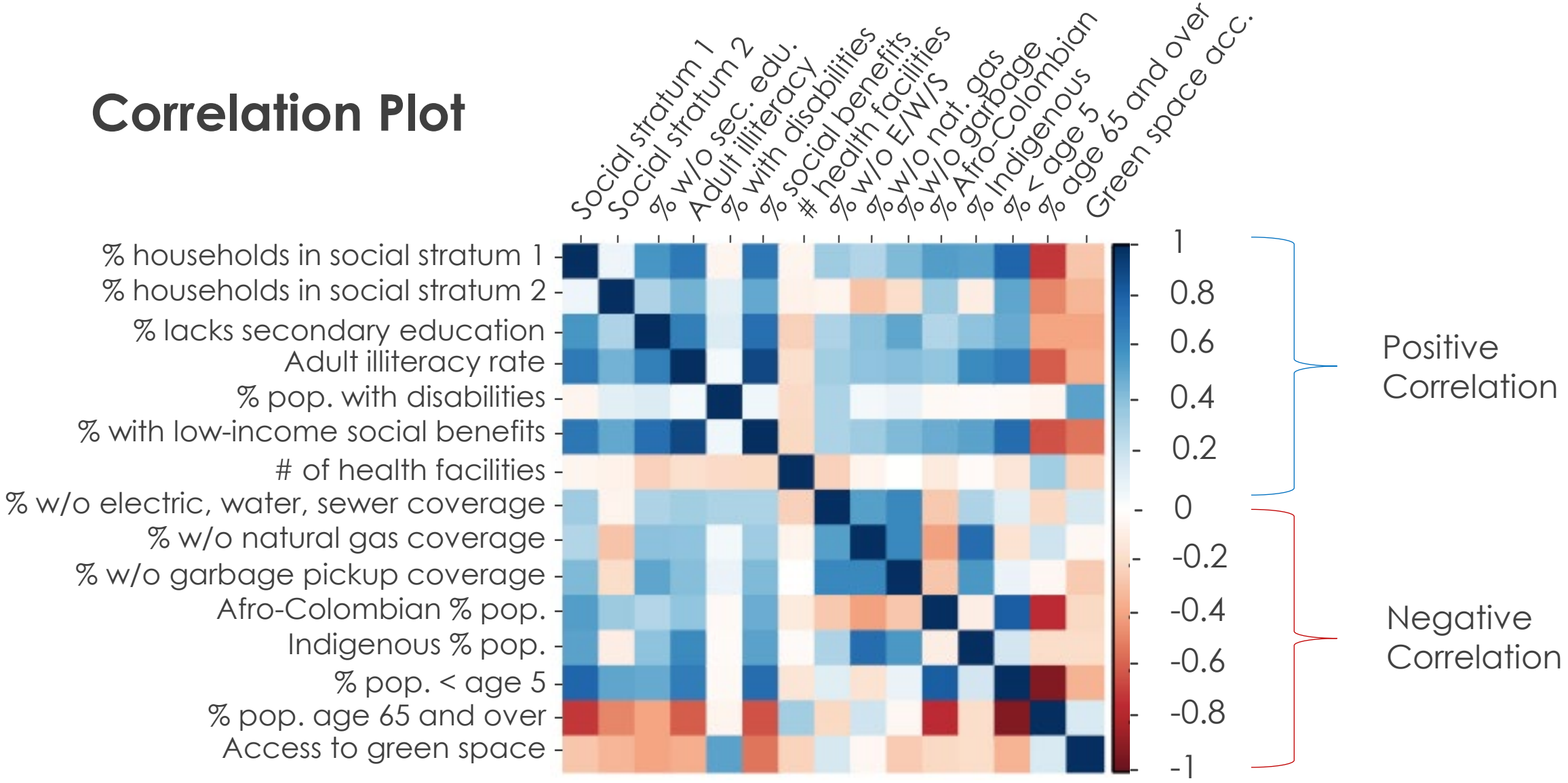
Analysis

Normalized Data and Ran PCA in R Studio

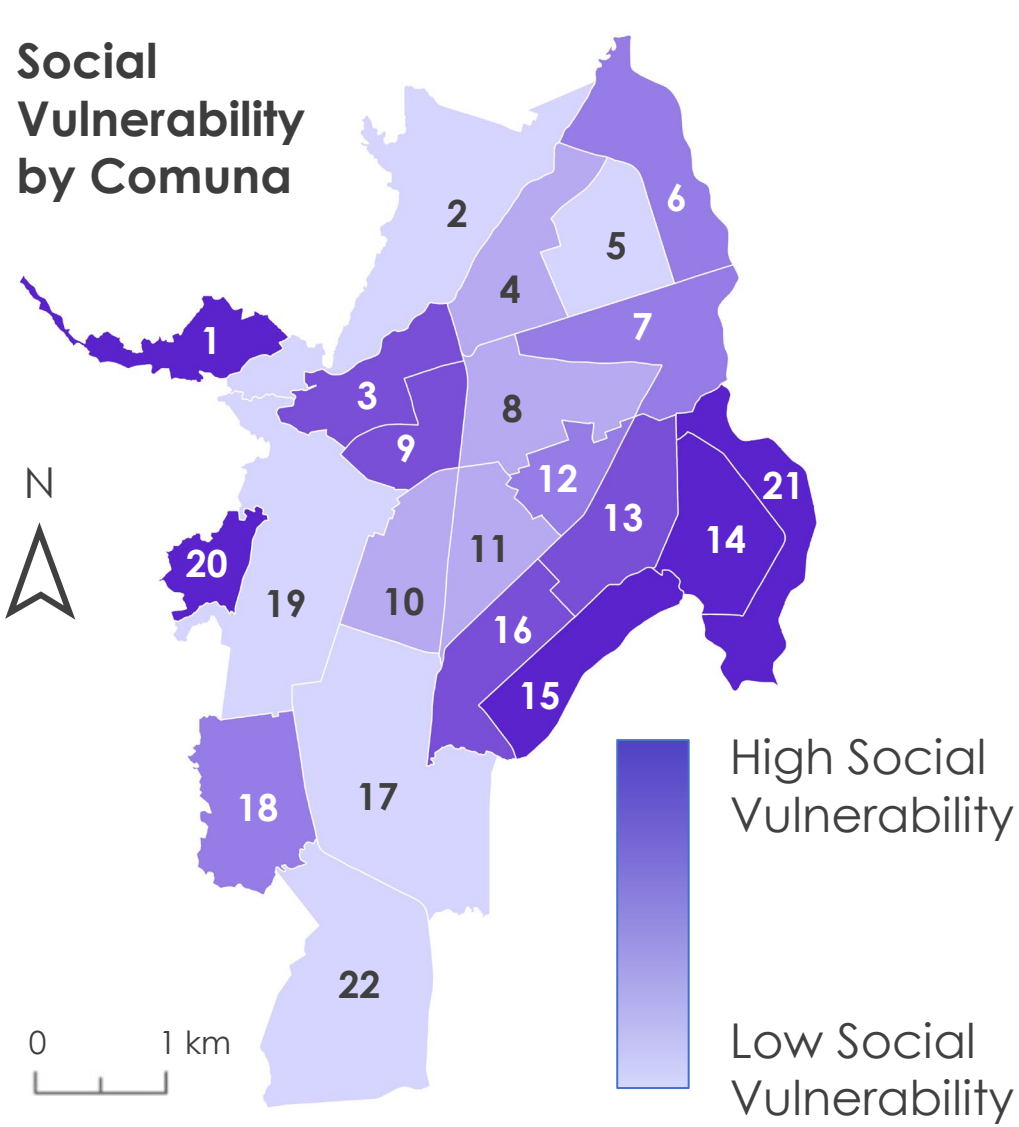
Visualized PCA Results in R Studio

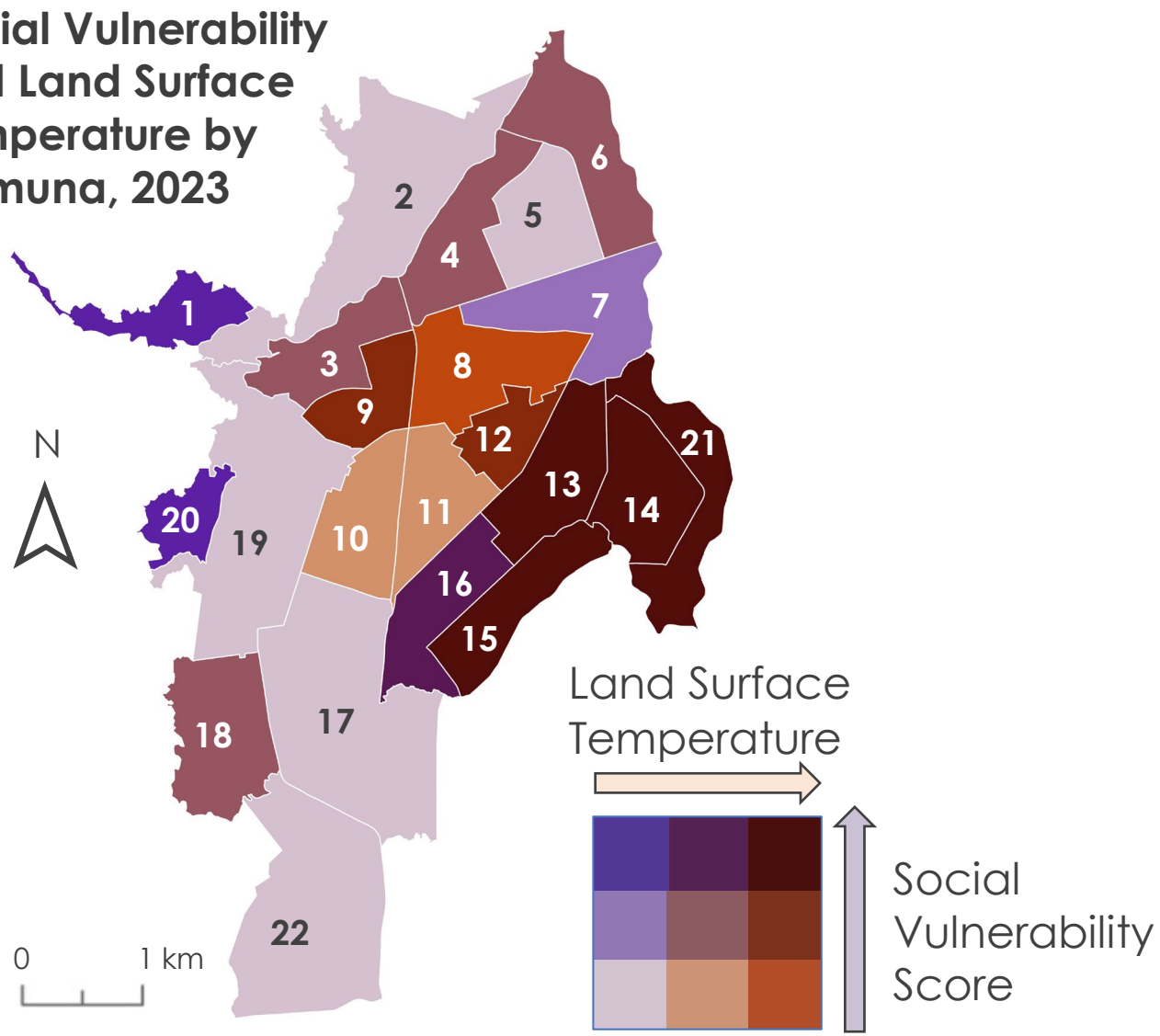
RESULTS: Social Vulnerability

Correlation Plot



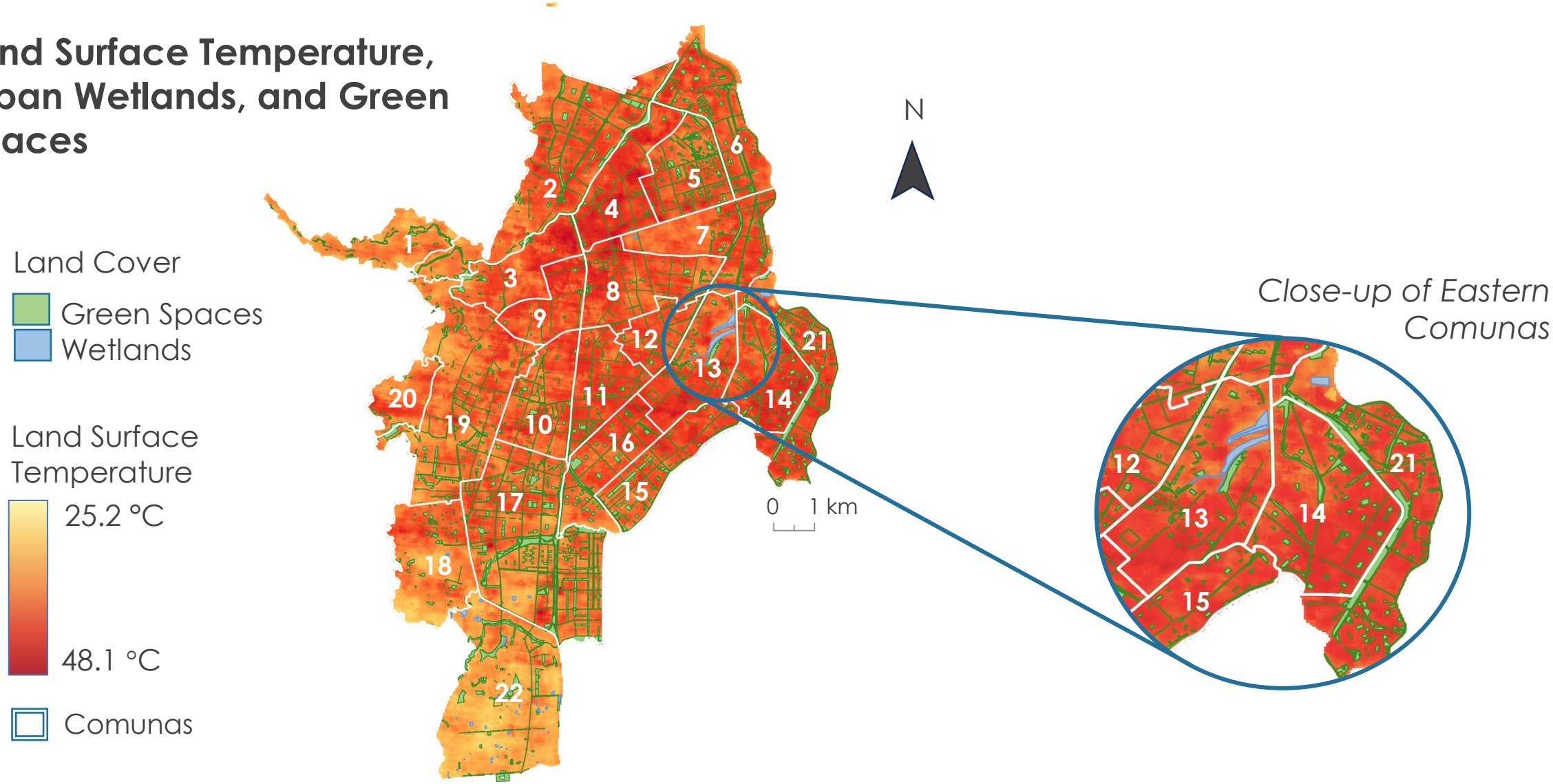
RESULTS: Social Vulnerability and Urban Heat





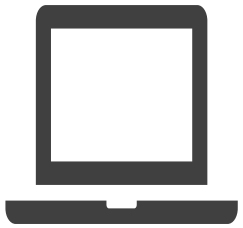
RESULTS: Social Vulnerability and Urban Heat

Land Surface Temperature, Urban Wetlands, and Green Spaces



LIMITATIONS

Cloud cover in satellite data



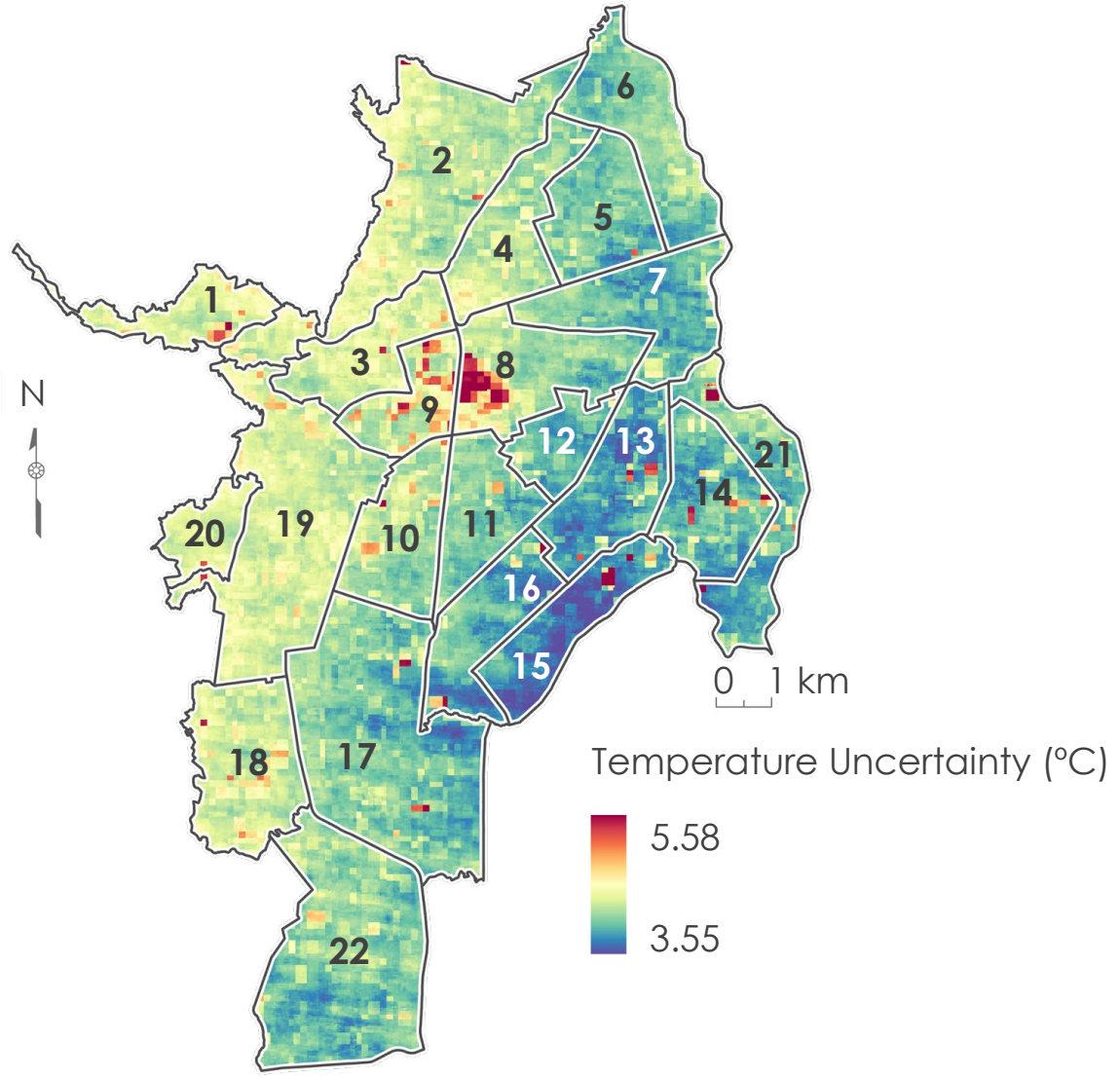
Deep Learning Model **trained with US data**

Years of availability for some education and health data

FEASIBILITY

Using NASA Earth observations in equatorial zones is limited by two major factors:

1. Minimal images to meet accuracy requirements
2. Temperature uncertainty



CONCLUSIONS

- Surface temperature varies according to land cover
- Amount of development significantly increases temperature
- Areas with less green space experience hotter temperatures and higher social vulnerability
- Highest need for expansion of green spaces and health facilities in Comunas 13-15 and 21
- Continued development exposes more individuals to high temperatures

Charco Azul

Image Credit: Viviana María Sánchez Escobar

Acknowledgments

The team would like to thank:

Partners: Fundación Dinamizadores Ambientales and Departamento Administrativo de Gestión del Medio Ambiente (DAGMA)

Advisors: Dr. Morgan Gilmour (NASA – ARC), Dr. Alexandra Christensen (NASA – JPL), Dr. Juan Torres-Pérez (NASA – ARC), Dr. Xia Cai (NASA – LaRC), Lisa Tanh (Esri)

Lead: Lauren Webster (California – Ames)

Fellow: Maya Hall (California – Ames)

Special thanks to the Spring 2024 Cali Urban Development I Team for their previous work on this project and the UHEAT Urban Development (Spring 2022) DEVELOP team for developing the UHEAT 2.0 Tool.

This material is based upon work supported by NASA through contract 80LARC23FA024. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.