Santa Clara County Exposure Vulnerability Index

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Introduction

Santa Clara County is widely recognized for its economic prosperity, yet stark socioeconomic and environmental disparities persist across neighborhoods. Low-income, immigrant, and historically marginalized communities, particularly in East San José and South County, face disproportionate exposure to extreme heat, air pollution, and infrastructure gaps.

This study develops a block group–level Social Vulnerability Index (SoVI) to identify where environmental exposure overlaps with socioeconomic disadvantage in Santa Clara County. Our goal is to support equity-centered resilience planning that reduces climate risk without contributing to displacement.

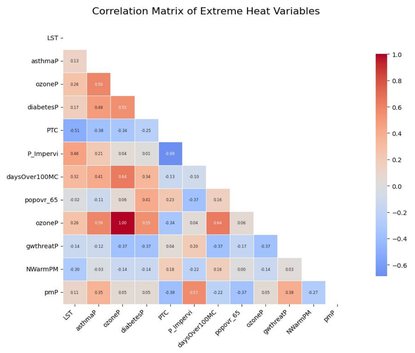
Research Questions

1. How can urban planning resolutions and/or ideas be implemented in lower-income/redlined communities in a way that protects property values while also not contributing to gentrification?
2. What barriers prevent residents in historically underserved or heat-burdened neighborhoods from accessing energy-efficient resources and electrification programs?
3. How do socioeconomic and environmental variables such as income, housing age, and tree canopy coverage contribute to differences in community climate vulnerability?

Methodology

Unit of Analysis: Census Block Groups (Santa Clara County)
Data Sources: American Community Survey (ACS), USGS Landsat (Land Surface Temperature), National Land Cover Database (Tree Canopy & Impervious Surface), CalEnviroScreen 5.0, EPA Air Quality Data, and Cal-Adapt Climate Projections
Steps: **(1)** Collect & harmonize block group data, **(2)** Standardize variables (z-scores), **(3)** Conduct PCA to identify dominant vulnerability patterns, **(4)** Construct SoVI composite score, **(5)** Map hotspots in ArcGIS

A



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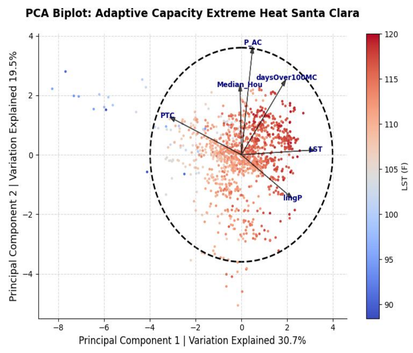

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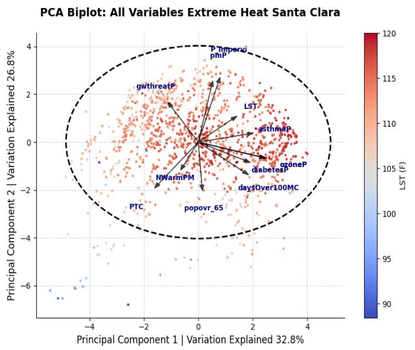

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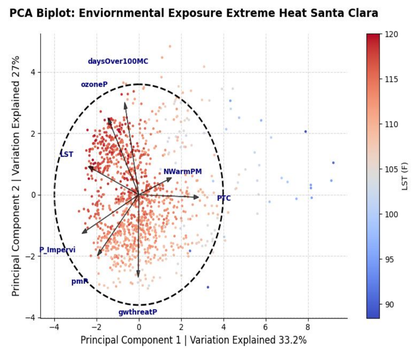

Figure 1a and b: Correlation Matrix of all 12 final variables and biplot of 1st and 2nd PCA. These two principal components explained almost 60% of the variation of our 12 variables. We calculated a vulnerability score using the eigenvalues and the values of PCA 1 and 2. The vector directions show how poverty and heat burden oppose adaptive capacity indicators.
Figure 1c: and d: Our Adaptive Capacity Model highlighted around 55% of variation. This model used biophysical variables such as tree canopy, impervious surface as well income and access to AC. Our Environmental Exposure Model had PC1 (33.2%) reflects a gradient of increasing heat exposure and air pollution burden, while PC2 (27.0%) distinguishes variation in precipitation and particulate matter patterns across block groups. The vector directions show how extreme heat indicators align with ozone and PM exposure, highlighting neighborhoods where environmental burdens cluster and contribute to heightened climate vulnerability.

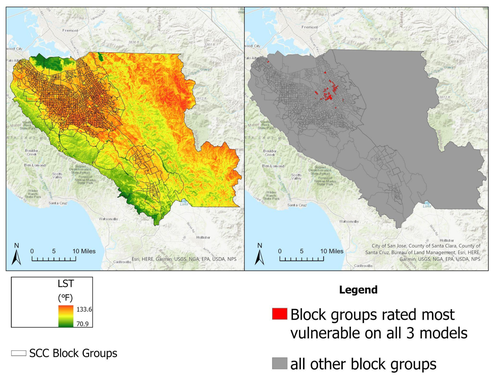

Figure 3a: LST + High Priority Block Groups. This figure shows the distribution of Extreme Heat in Santa Clara County during the Early October 2024 Heat wave in which Santa Clara County saw temperatures above 100 degrees Fahrenheit for 4 consecutive days. The right panel map shows the block groups that were rated as most vulnerable all 3 of our PCA Model runs

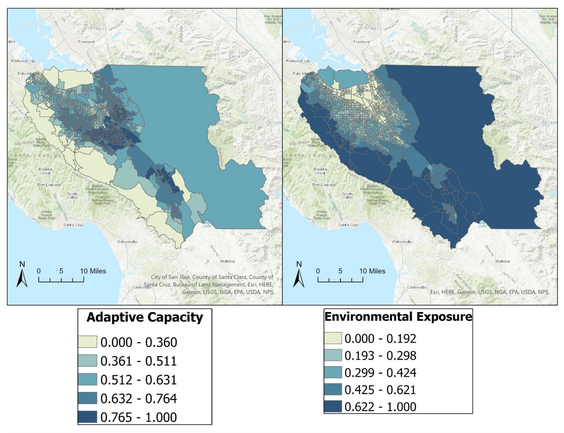

Figure 3b: Adaptive Capacity Variables + Environmental Exposure Variables

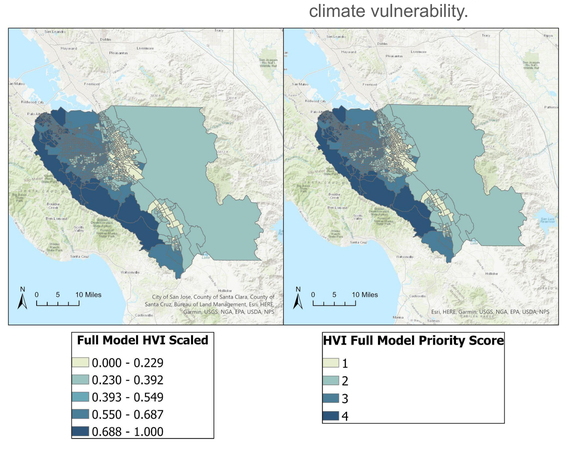

Figure 3c: Priority Block Group Scaled + Priority Block Group Unscaled

Vulnerability	Averages (High-Priority Block Groups)
Non White Population (%)	82.5%
LST	114°F
Tree Canopy (%)	7.5%
Mid-Century Days over 90°F	49 days
AC Access (%)	60% [compared to 89% total county access]

SoVI Findings

The PCA analysis reveals the existence of a “heat-pollution cluster” that accounts for 33.2% of the total variance. This cluster is defined by areas there high average LST (114°F) will occur at mid-century (based on projected data) coinciding with an increase in ozone and PM concentrations. One point where these two types of burden occur within the block groups that has a non-white population of 82% and only 7.5% tree canopy cover. The analysis also shows that there is a significant “cooling gap” within the county. While 89% of the county’s residents have access to air conditioning, access to air conditioning drops to 60% for the residents living within these priority regions. The results of the PCA analysis demonstrate that there are multiple types of vulnerability for these Santa Clara County residents due to the intersection of environmental exposure and structural socio-economic gaps.

Analysis

The spatial pattern of vulnerability reflects historic patterns of segregation, disinvestment, and uneven infrastructure development.

Key drivers of vulnerability include:

- Lower median household income
- Higher renter occupancy
- Limited tree canopy
- Reduced access to cooling resources
- Higher asthma and air pollution exposure

Our PCA results confirm that vulnerability is multidimensional and cannot be explained by income alone. Environmental exposure and adaptive capacity significantly shift neighborhood risk profiles.

Conclusion

This study demonstrates that climate vulnerability in Santa Clara County is shaped by the interaction of environmental exposure and structural inequality.

Key Takeaways:
1) Vulnerability is spatially concentrated.
2) Heat exposure overlaps with socioeconomic disadvantage.
3)Adaptive capacity (cooling access, greening, nfrastructure) significantly reduces risk.

Policy Implications:
- Target greening and cooling infrastructure investments in high-priority block groups
- Expand culturally informed outreach for energy-efficiency programs
- Design anti-displacement safeguards alongside climate adaptation investments
- Equity-centered climate planning must address structural drivers of vulnerability rather than treating heat exposure as an isolated environmental issue.

Recommendations

In order to address the 29% cooling gap, Santa Clara County should install cooling infrastructure and hydration stations in “Extreme Priority” zones (such as East San Jose) first. Urban greening efforts should be focused on areas that currently have below 10% tree cover where the average land surface temperature is 114°F. To ensure equal treatment, the County should partner with local organizations in order to bring bilangual energy-efficeient outreach to renters and isolated households. Furthermore, to prevent gentrifications brought upon by these improvements and climate change, any resilience investments should include strong anti-displacement measures and localized heat health alerts that incorporate air quality data.