# Optimization of Police Resources in Commercial Areas of Bogotá

## Geospatial and Strategic Analysis of Vulnerabilities


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## About Bogotá

**Population:** 8+ million (metro area: 11+ million)

**Area:** 1,775 km²

## Challenges

**High urban density** + extensive commercial activity

**Limited police resources** vs. growing urban needs

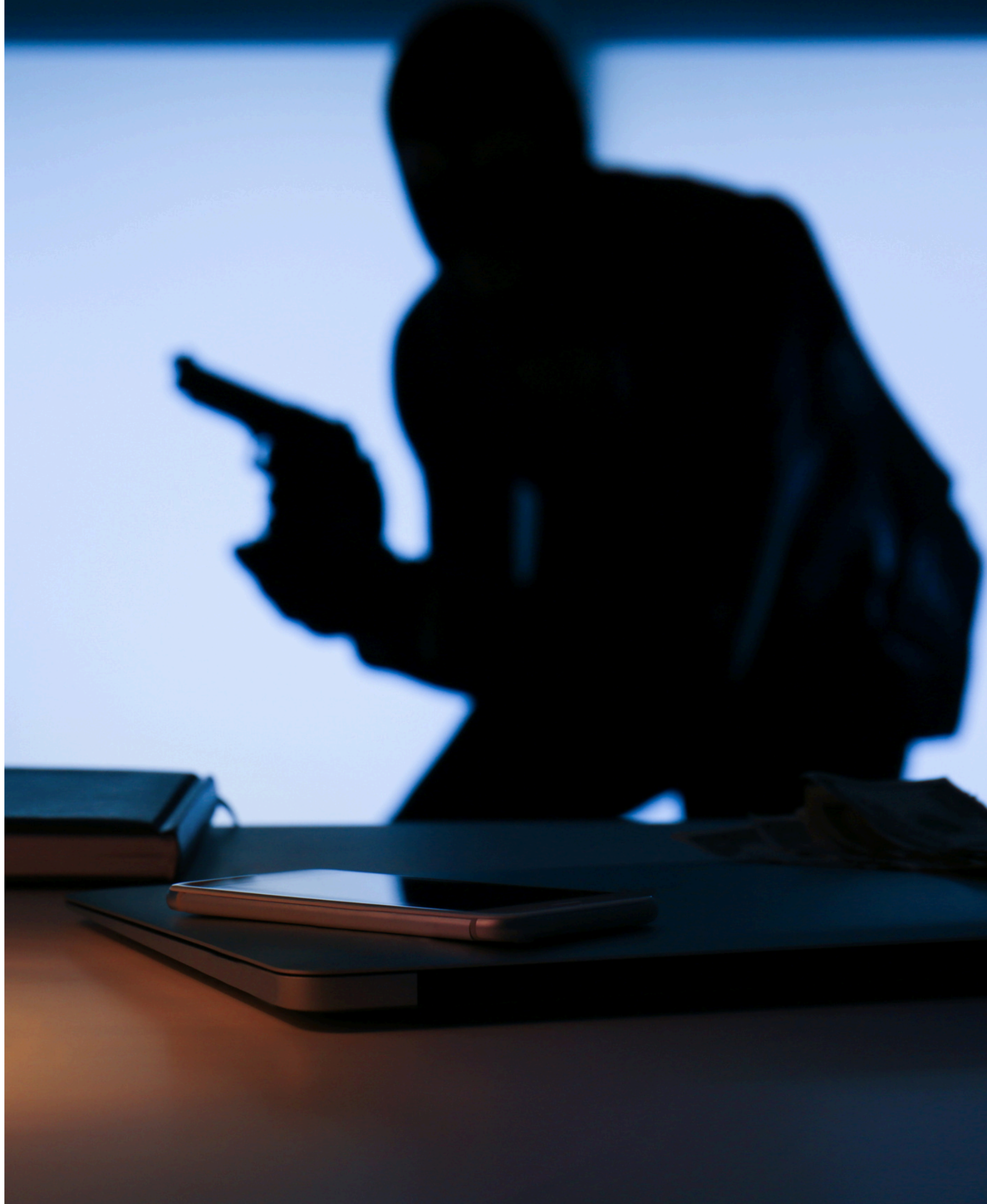
## Bogotá's Reality

Colombia's capital faces escalating theft in commercial districts some areas like Mártires saw +34.1% increase in one year. High traffic zones have become crime hotspots where businesses struggle to operate safely.

## The Challenge

Business owners struggle while police resources remain stretched thin

- Security ranked as #1 operational obstacle, companies cannot attract employees to vulnerable zones
- Police deployment follows administrative boundaries, not commercial activity patterns or crime data



## Current Situation

- Security studies focus on general localities or neighborhoods
- No specific analysis of commercial zones as critical points
- Police deployment based on administrative boundaries, not commercial activity patterns

## Our Approach

- Identify natural clusters of commercial activity, not administrative boundaries
- Apply graph theory to map station-zone connectivity and identify vulnerabilities
- Create clear CAI-zone pairings that balance workload and minimize response times

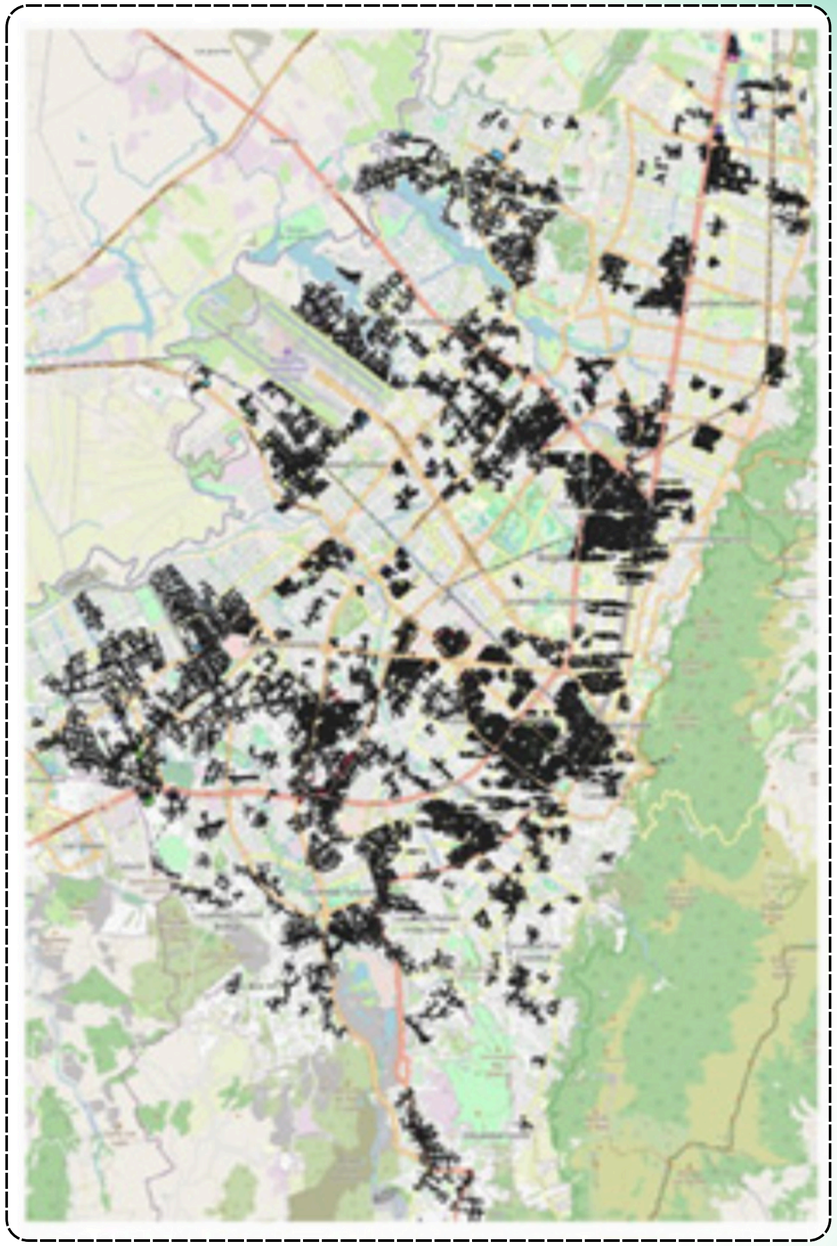
# Methodological Framework

**Three phase pipeline integrating geospatial clustering with graph theory to optimize police resource allocation and improve response times at lower cost.**

1. **Commercial Zone Identification**
2. **Security Network Construction**
3. **Strategic Optimization**

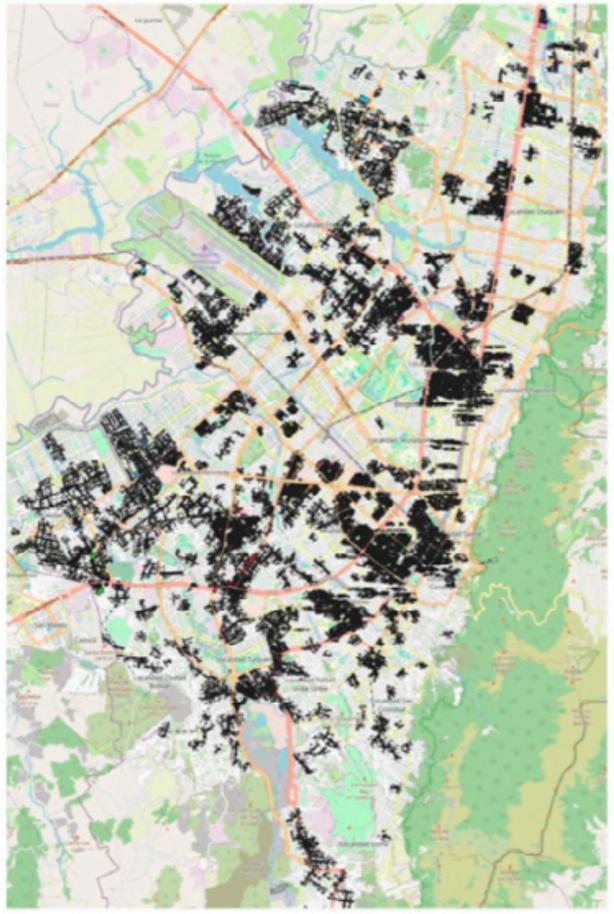
*Data utilized:*

- *Cadastral database: 2022 commercial buildings (4 categories: retail, commercial corridors, shopping centers, industrial)*
- *Police infrastructure: 100+ CAI stations and main police stations in Bogotá*
- *Validation: Probogotá Security Report 2022 + crime statistics*



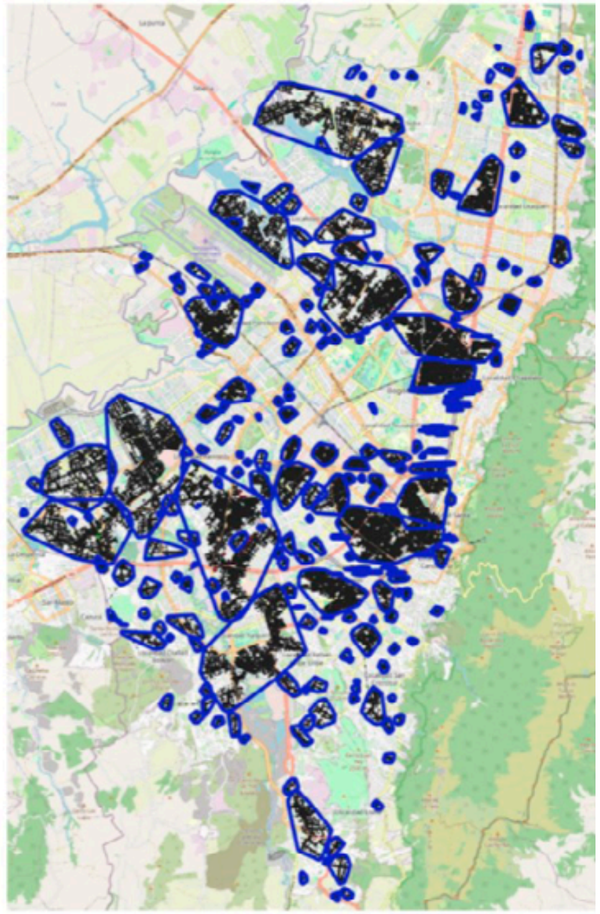
## Commercial Buildings Data

- Cadastral registry (2022)
- 383k+ records filtered
- 4 commercial categories



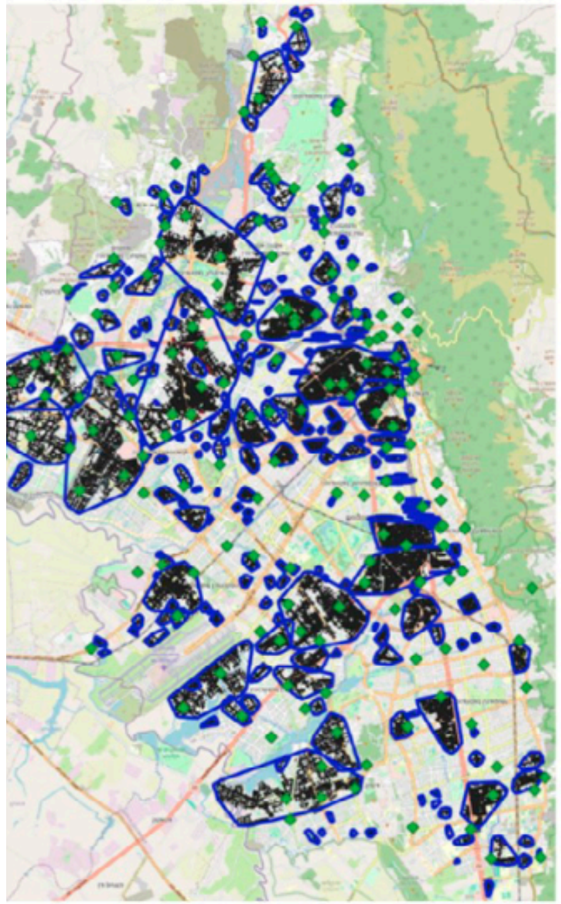
## DBSCAN Clustering

- Density-based spatial clustering
- Parameters: ε-distance, min_samples
- Output: 241 commercial zones



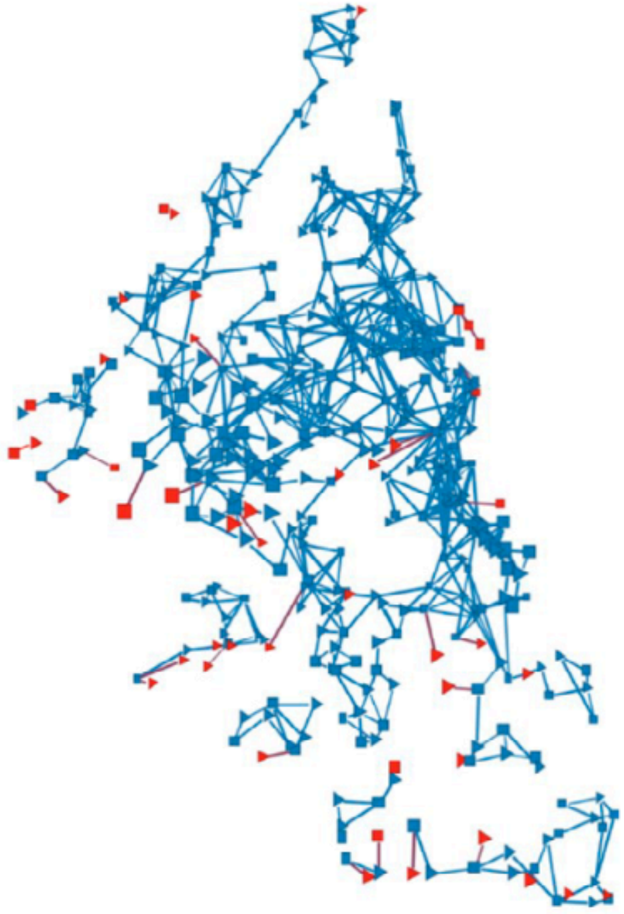
## Network Construction

- Zone centroids (blue) extracted
- CAI stations (green) overlaid
- 8-minute connectivity criterion



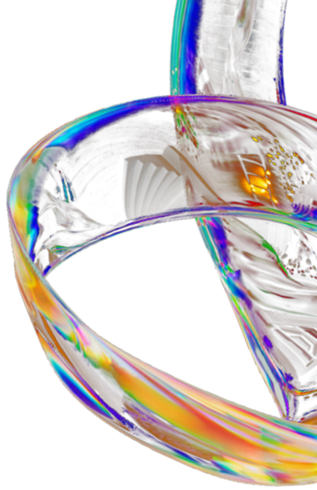
## Graph Model

- Nodes: CAI (red) + Zones (blue)
- Edges: travel time ≤ 8 min
- Weighted network ready for analysis



# Strategic Network Optimization

Applying graph algorithms to identify critical positions and create optimal CAI-zone assignments



1

## Eigenvector Centrality

**$Ax = \lambda x$ (A = adjacency matrix, λ = largest eigenvalue)**

Node importance determined by importance of connected neighbors. Identifies CAI stations protecting critical commercial zones.

2

## Degree Centrality

**$C(v) = deg(v) / (n-1)$**

Counts direct connections per node normalized by network size. Reveals workload distribution and overloaded stations.

3

## Closeness Centrality

**$C(u) = 1 / \Sigma\, d(u,y)$**

Measures average distance to all other nodes in network. Identifies isolated zones with poor accessibility.

3

## Stable Matching (Gale-Shapley)

**CAI (capacity k) ↔ Zones (preference by distance)**

Creates optimal assignments guaranteeing no pair prefers switching. Produces balanced workload with clear operational responsibility.

# Key Findings

## Strategic Backbone:

**CAI Ciudad Berna, Distrital, and Restrepo** emerged as most strategically important (eigenvector >0.240), protecting Bogotá's economic core and requiring priority resource allocation.

## Severe Overload:

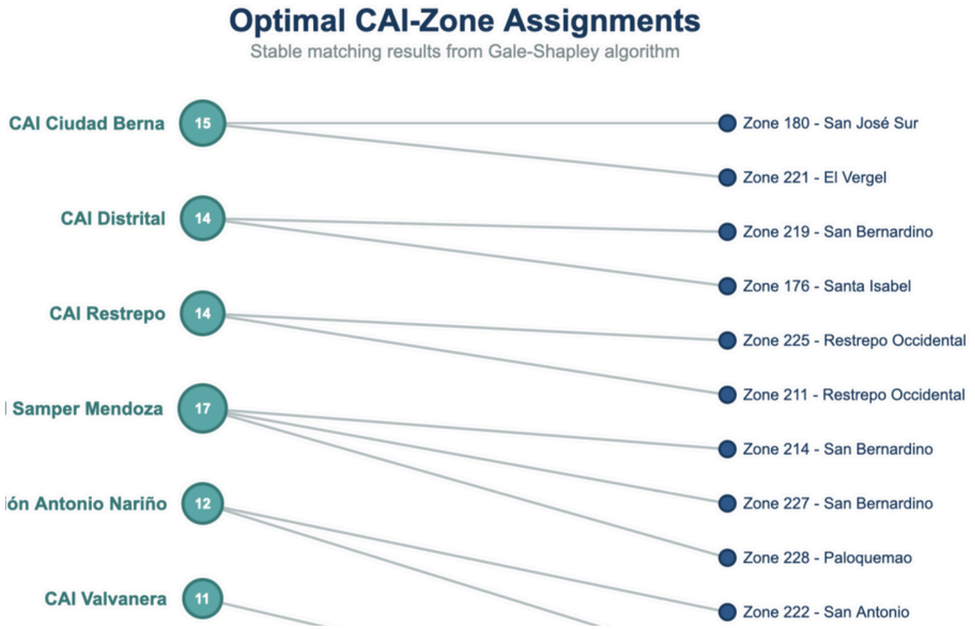
**CAI Samper Mendoza** covers 17 commercial zones in Los Mártires—the city's most insecure locality—facing critical workload imbalance that demands immediate reinforcement.

## Peripheral Vulnerability:

Commercial zones in Suba, Usme, and Ciudad Bolívar show lowest centrality scores with poor CAI connectivity and response times exceeding 6 minutes.

## Coverage Gaps:

Three zones located beyond 4.5km from any CAI station create blind spots in the security network, requiring mobile patrol units or new infrastructure investment.



# NEXT STEPS

1

## Temporal dynamics

Integrate time series to capture crime patterns across different periods and adjust allocations dynamically

2

## Scalability to other cities

Apply methodology to Medellín, Cali, and other Latin American megacities

3

## Multi-layer network modeling

Combine pedestrian flow, vehicle traffic, and crime networks to understand multi-dimensional security dynamics

# THANK YOU

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