MAPPING URBAN FIRE RISK

CITY OF SANTA FE, ARGENTINA

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INTRODUCTION

- **Santa Fe** (Fig. 1) currently lacks specific protocols designed to address **urban fire risk** (hereinafter referred to as **UFR**).
- Local authorities face **significant challenges**, including: (i) densely populated areas with narrow streets, (ii) the use of substandard construction materials, (iii) non-compliant electrical and gas installations, (iv) aging residential buildings in the city center, (v) illegal burning of grasslands and garbage in the street, and (vi) facilities handling hazardous substances located within residential areas.
- This study aims to **develop the first UFR mapping model of Santa Fe, Argentina, integrating expert knowledge.**

STUDY AREA

Fig. 1. Location map of the City of Santa Fe

METHODOLOGY

An R script was developed to automate the data processing and analysis workflow

Geographic Information System

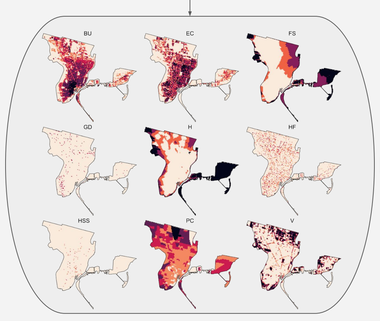
Intersect the geometries to **obtain values for each grid cell**

100-meter spatial resolution grid

Intersect

VECTORIAL DATA / CRITERIA

n = 9



(x_i)

Analytic Hierarchy Process

Pairwise comparisons to **determine the weight of each criterion**

Pairwise comparison

Experts

Square matrix

Calculation of average weight (w_i)

Calculation of Consistency Index (CI) and Consistency Ratio (CR)

If CI and CR ≤ 0.1

True

False

$UFR_i = \sum x_i \times w_i$

Jenks technique: 5 intervals = 5 risk levels

UFR map Fig. 2

One-At-a-Time Technique

(i) **Assess the stability** of the initial hierarchical classification of criteria
(ii) Identify the criteria that exhibit **the highest responsiveness**
(iii) **Detect changes in cell classification** according to risk level

Variation of ±1% within a range of ±20%

Proportional adjustment: sum of weights = 1

Prioritization order Fig. 3

Quantity of cells per risk level Fig. 4

VECTORIAL DATA / CRITERIA

BU: Building footprint (m^2)
EC: Electrical cable in public spaces (m)
FS: Distance to fire station (min)
GD: Garbage dump (Qty)
H: Distance to hydrant (min)
HF: Historical fire (Qty)
HSS: Hazardous substances supplier (Qty)
PC: Population census (Qty)
V: Vegetation (m^2)

RESULTS

CI: 0.0772

CR: 0.0533

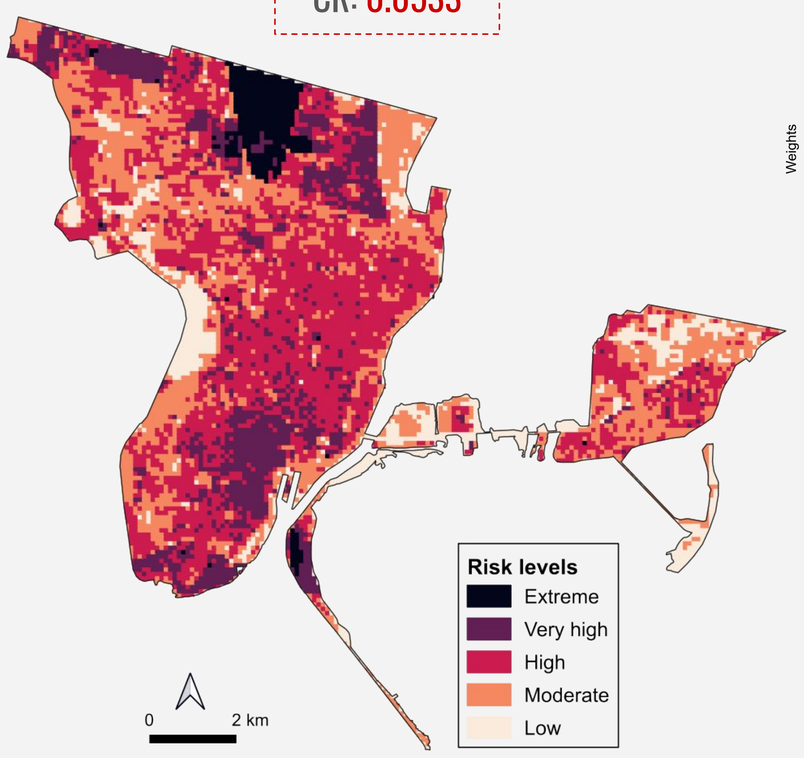


Fig. 2. Spatial distribution of the five levels of fire risk in the City of Santa Fe

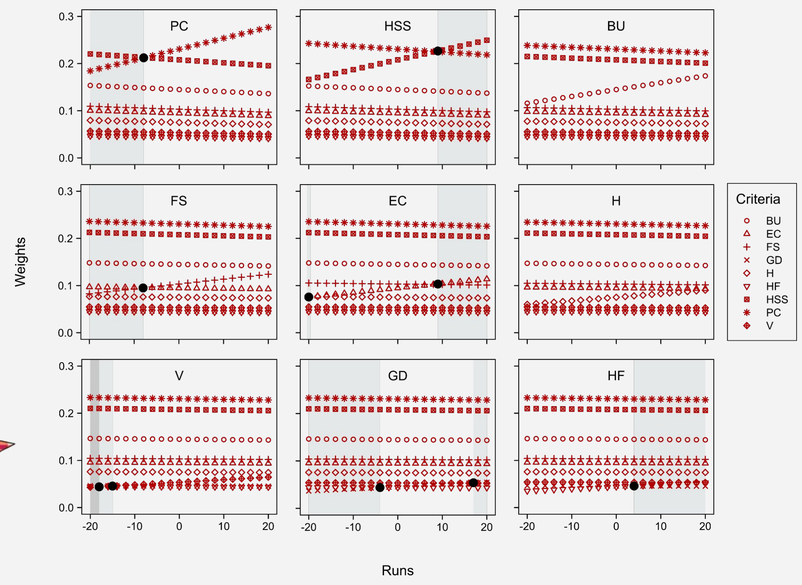


Fig. 3. Changes in prioritization criteria order

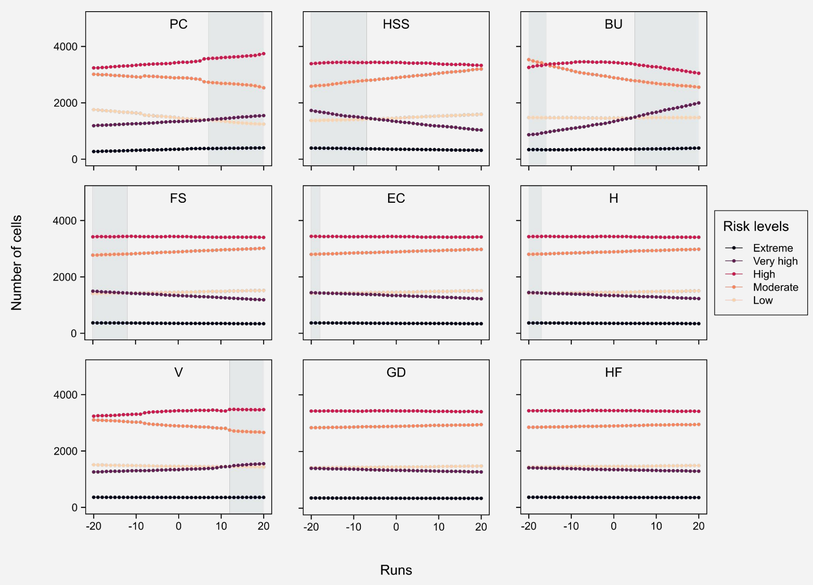


Fig. 4. Changes in the quantity of cells per risk level

- **Underpopulated areas** are characterized by a **low-risk level**
- **36.39%** of the city is classified as **high risk**
- The **city center** exhibits a **very high-risk level**
- **Two major neighborhoods** are categorized as **extreme risk**

- **Contribution to fire risk**: PC (**23.1%**), HSS (**20.8%**), BU (**14.5%**), FS (**10.3%**), EC (**9.5%**), H (**7.5%**), V (**5.4%**), GD (**4.6%**), and HF (**4.4%**)
- **EC**, **GD**, and **V** are **highly sensitive** to both positive and negative variations in their weights
- **BU** and **H** **maintain stable positions** in the classification despite variations in their weights

- **Low-risk level**: ↘ cells if ↗ weight of **PC** and **V**
- **Moderate-risk level**: ↘ cells if ↗ weight of **PC**, **BU**, and **V**
- **High-risk level**: ↗ cells if ↗ weight of **PC** and **V**
- **Very high-risk level**: ↗ cells if ↗ weight of **PC**, **BU**, and **V**
- **Extreme-risk level**: ↗ cells if ↗ weight of **PC**

CONCLUSIONS

Recommendations: (i) **Evaluate** and **anticipate** potential future changes in UFR zoning, (ii) **reverse the trend** of a large portion of the city currently classified as high-risk areas, and (iii) **implement stricter regulations** based on key criteria to effectively reduce substantial threats to public security.

Santa Fe needs a comprehensive strategy that integrates both authorities and the community, aimed at increasing community resilience and adapting infrastructural systems in response to demographic growth and rising extreme temperatures, which may exacerbate the UFR.

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