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Building a Historical Flooding Map through Spatial Analysis

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Historical Flood Map

→ "Where" and "when" significant flood patterns and trends are taking place

→ 1st Law of Geography:
"Everything is related to everything else, but near things are more related than distant things"

Study case: Campina Grande, Brazil

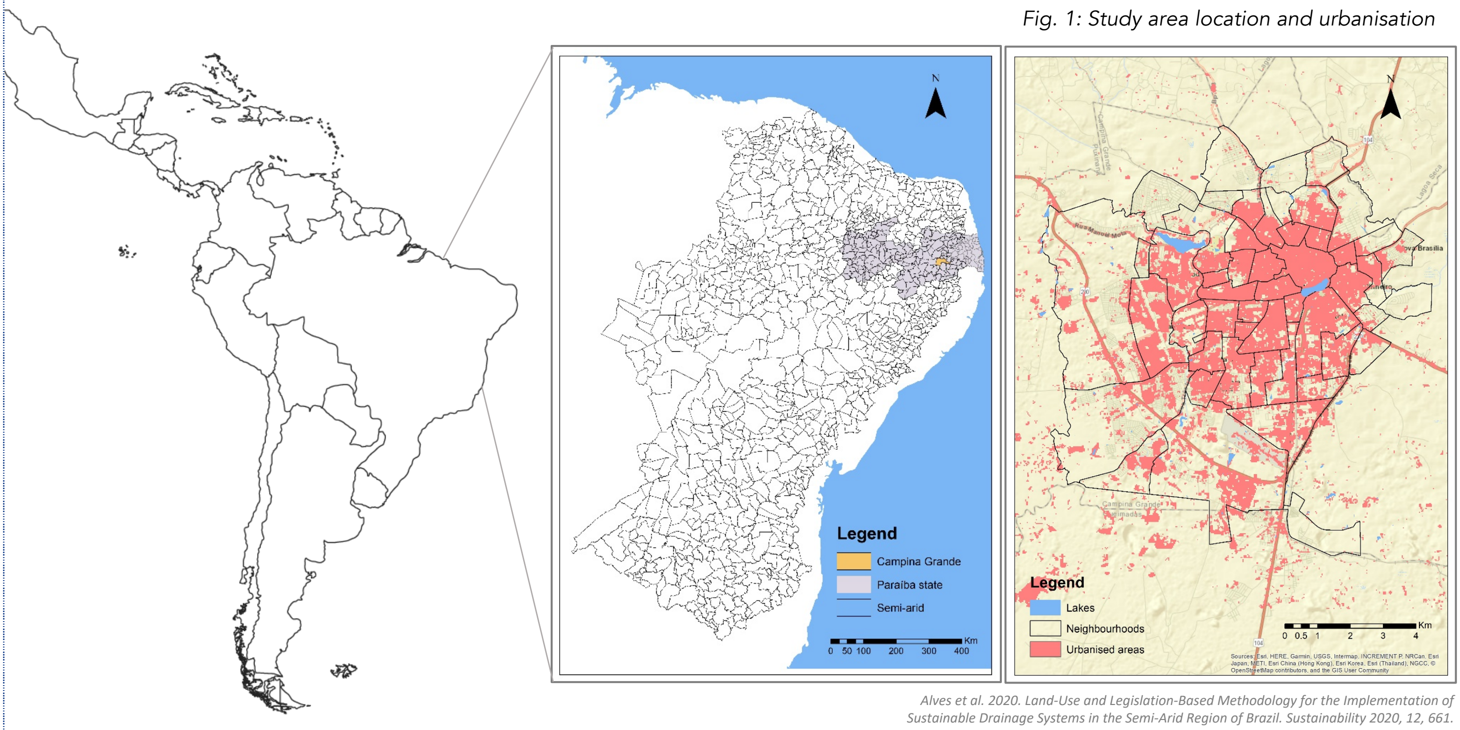


Fig. 1: Study area location and urbanisation

Alves et al. 2020. Land-Use and Legislation-Based Methodology for the Implementation of Sustainable Drainage Systems in the Semi-Arid Region of Brazil. Sustainability 2020, 12, 661.

- City with recurrent flooding cases;
- The city has official risk areas mapped but flood cases are also seen in many other locations;

Goal:

- To build a historical flooding map for Campina Grande-Brazil with a GIS-collaborative approach;
- To identify trends of flood cases, over time, by applying techniques of spatial analysis.

Framework:

Data collection → Data mapping → Data verification → Spatial data analysis

Software: ArcGIS Pro (ESRI)

Fig. 2: Historical flood map framework

1. Place-based citizen science project

The "Planejeee Project": To Plan Extreme Events
Collection of data with the assistance of stakeholders
May-June of 2019 - Campina Grande, Brazil

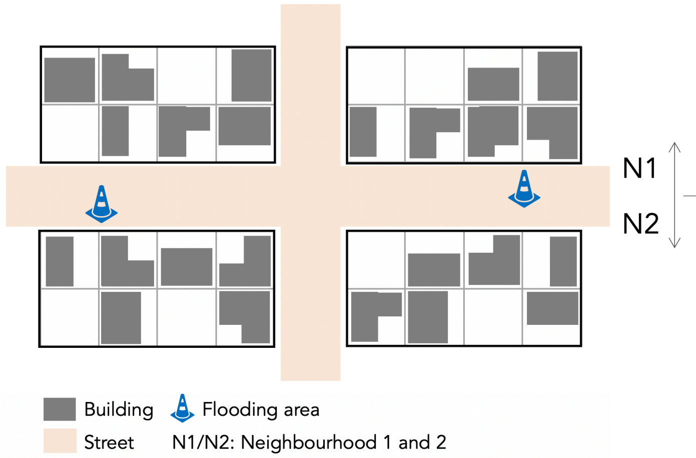
172 surveys with residents
27 policymakers and specialists

Collaboration platforms: in person surveys and workshop, informal meetings, website, online survey and social media

Mixed-source information data:
Flooding complaints I Flooding reports I News and Social Media
Mixed flooding-scale data:
Buildings I Streets I Neighbourhood

2. Managing uncertainties:

2.1 Conceptual analysis for data mapping:

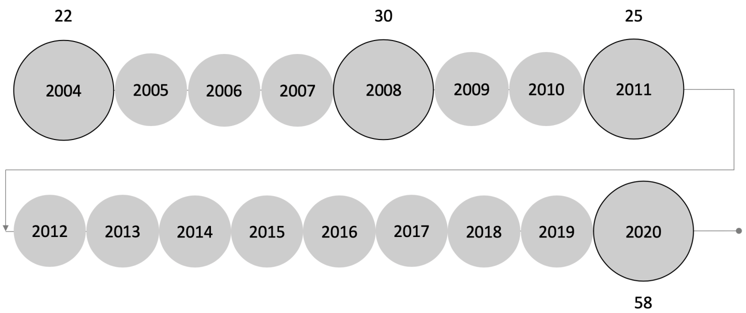


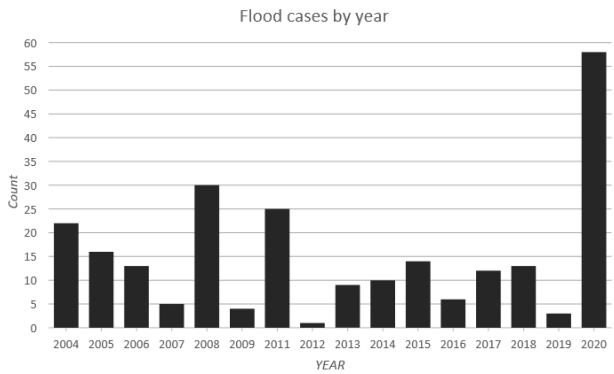
Assumptions:
(1) and (2): Most flooding cases occur in a part of a street (not in the entire street) - same rule was applied for neighbourhood-scale data;
(3): It is unusual that only one building has flooding in a street/neighbourhood;
(4) When it is not possible to find the correct part of the street to map, the data will be discarded.

Fig. 3: Conceptual analysis

Fig. 4: Time-scale of analysis (2004-2020)
Fig. 5: Number of floods per year

2.2 Final time-scale:





3. Mapping:

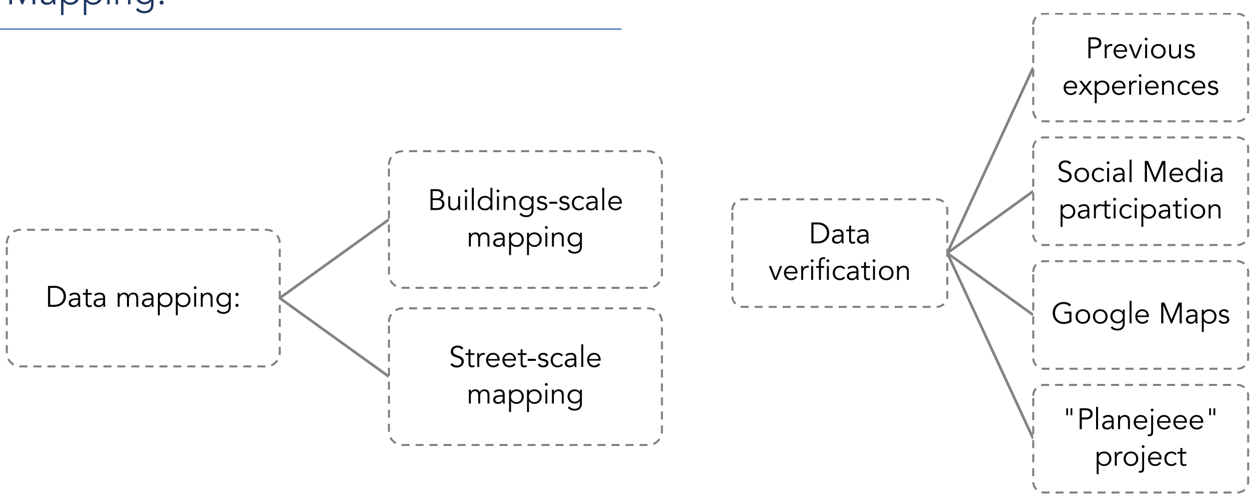
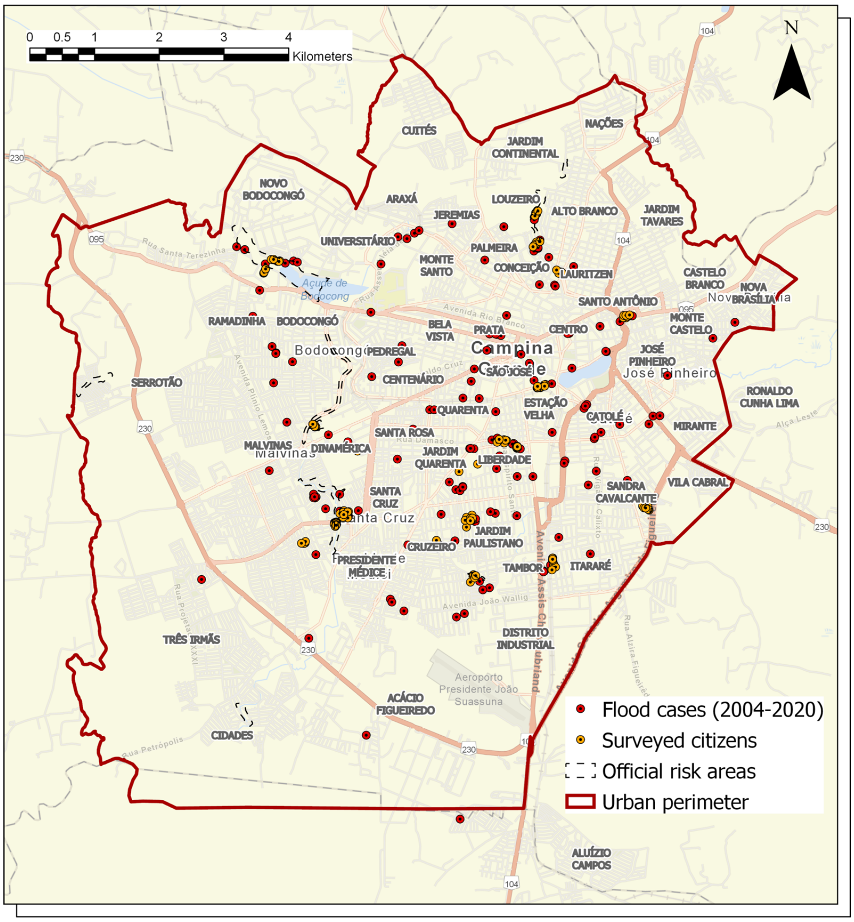


Fig. 6: a) Steps for data mapping; b) Steps for data verification

Fig. 7: Historical flood map (2004-2020) and residents interviewed



Data:
N (Flood cases) before = 266
N ("Planejeee" Project) = 172
N (Flood cases) after Mapping and Verification = 241

N flooding total = 413

4. Spatial data analysis:

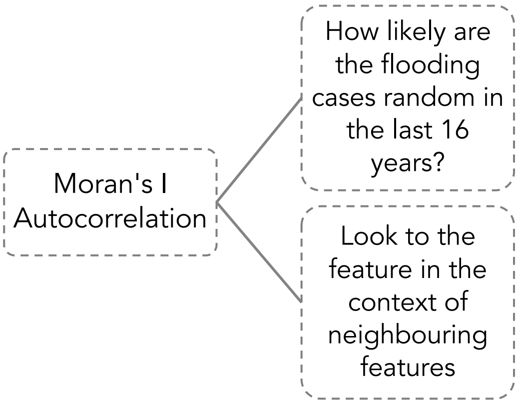


Fig. 8: Moran's I research questions scheme

Index either positive (clustered) or negative (dispersed) (+1 and -1)
Moran's I Index is statistically validated with z-score and p-value
Assumption: Data values are independent and randomly arranged in the geographical space.

4.1 Spatial analysis aggregation:

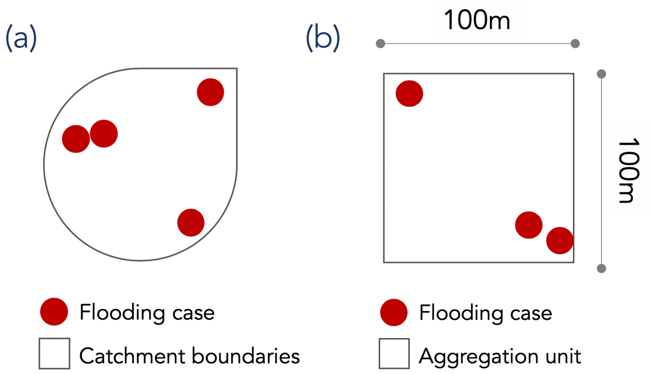


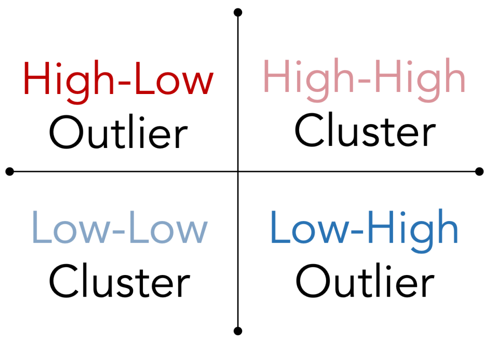
Fig. 9: a) Catchment aggregation; b) 100mx100m fishnet aggregation

(i) Each flooding case represent the attribute 1 in a year (from 2004 to 2020);
(ii) Each aggregation unit/catchment has a unique spatiotemporal extent (from 2004 to 2020);
(iii) Flood occurrence is analysed in different years in order to statistically find clusters and outliers.

4.2 Conceptualisation:

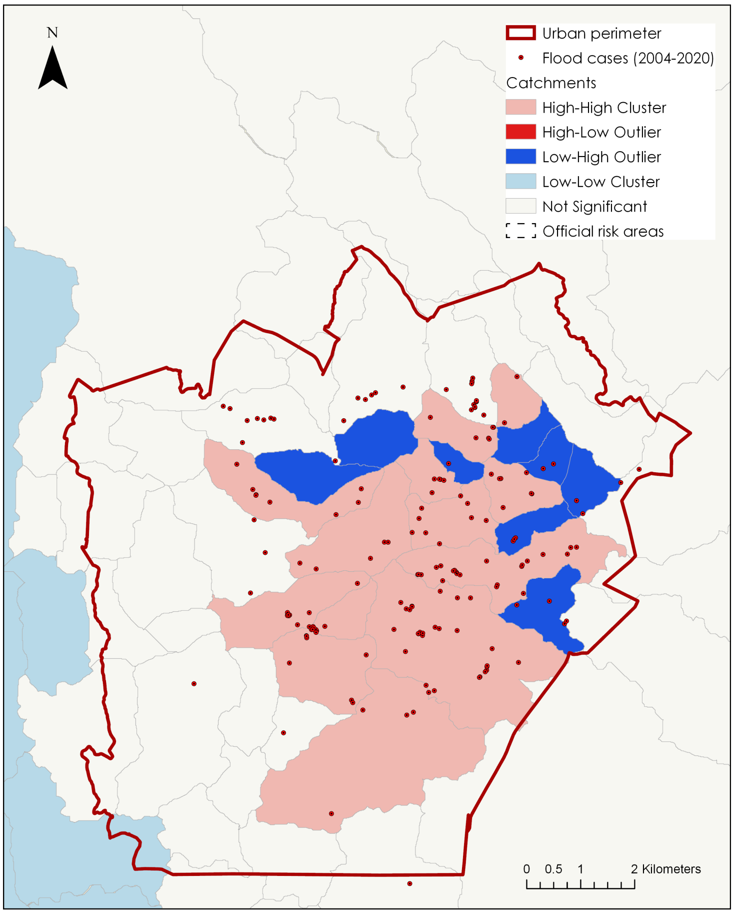
Outliers: Locations very different from their surroundings;
Clusters: Locations with the same attribute as their surroundings;
Multiple types: Locations where has been multiple types of statistically significant clusters and outliers throughout the time.

Fig. 10: Scheme for cluster and outlier analysis



4.3 Results:

Fig. 11: Clusters and outliers catchments



Analysis (a):

Most catchments present a high-high cluster, what indicates they are statistically significant locations with flood cases surrounded mainly with other high-high catchments.

Analysis (b):

The approach identified several locations with high clusters, outliers and multiple types far from the official risk areas of the city; this indicates key areas for the flood management of the city; and a need for updating the current risk areas mapping.

Fig. 12: Number of clusters and outliers for fishnet aggregation

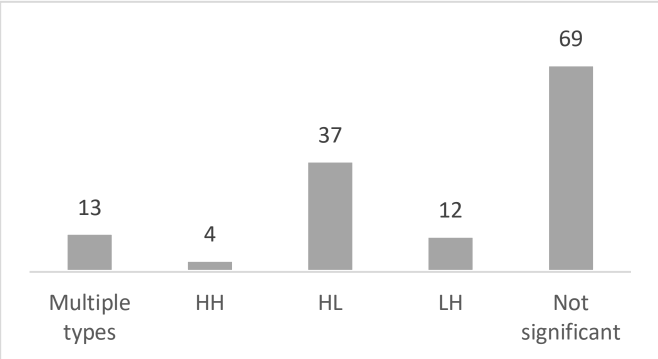
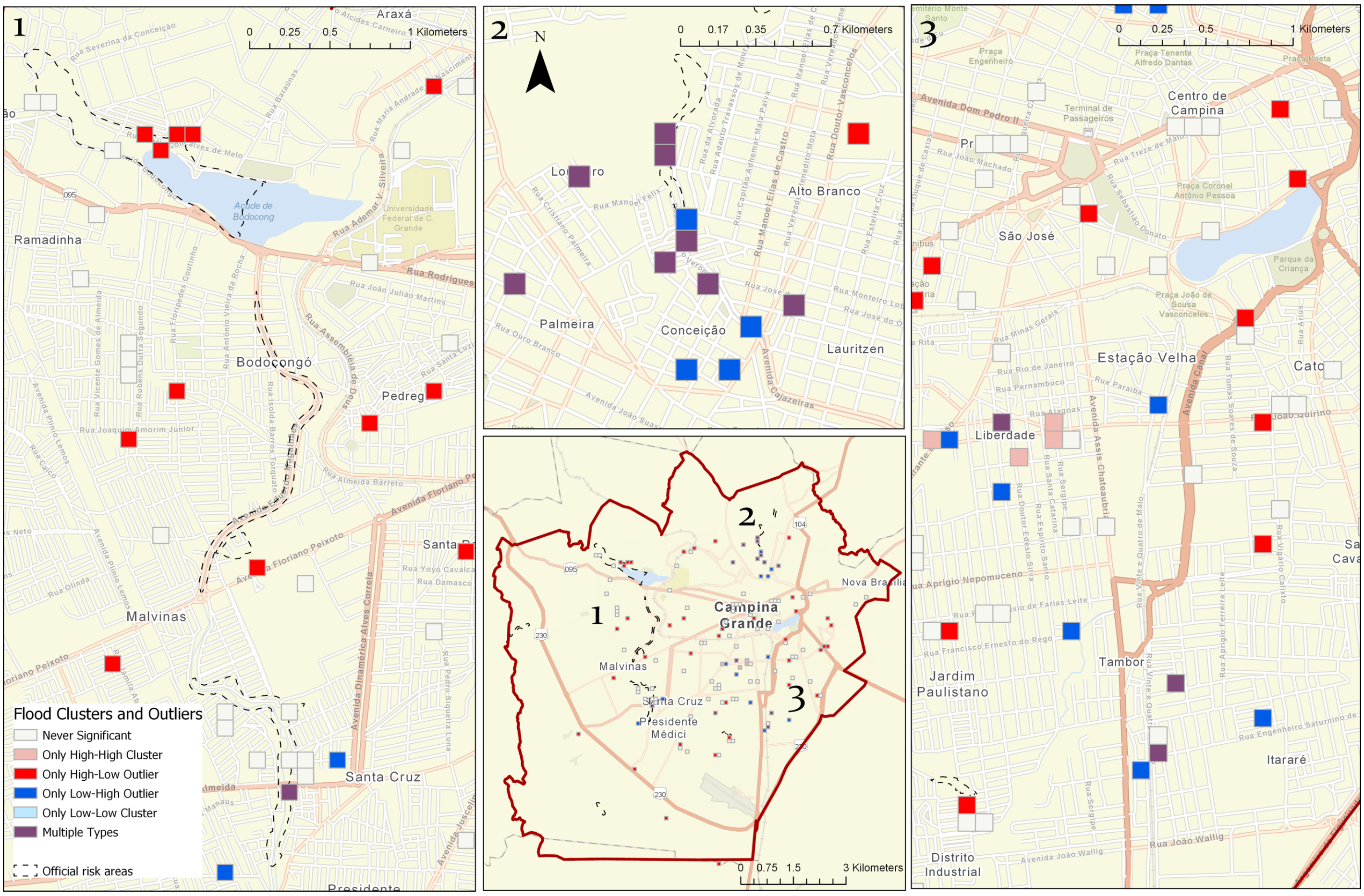


Fig. 13: Spatial representation of clusters and outliers (100mx100m)



5. Conclusions and next steps:

GIS-Collaborative approaches have a positive impact in water management, including obtaining data, understanding better the current context and identifying trends over time;
Clusters and outliers will be further analysed with physical and social variables, such as elevation, slope, income and imperviousness, to understand other influences in floods.