Centrality analysis on Rio Grande do Sul

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2025-01-01

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Data and Software Availability

This document is written following the Reproducibiltiy paper guidelines for the AGILE conference 2025 (Belliard et al. 2019) .The following flowchart explains the methodology to analyse the centrality and resilience of the road network and healthcare facilities in the core metropolitan area of Rio Grande do Sul.

1. **Select Area of Interest (AOI)** includes importing the flood extent, municipalities and the road network affecting the core metropolitan area of Porto Alegre. We name core metropolitan area to the 9 municipalities in the urban dense human settlement that intersects with the municipality of Porto Alegre.
2. **Obtain routable network** created the two output post-disaster and pre-disaster network. Firstly, OpenRouteService is used to transform the OpenStreetMap data into a routable graph named pre-disaster network. Extracting the difference between the flood extent obtained in the previous lane with the pre-disaster network generated the post-disaster network. Both road networks are graphs, which allow to use the extension pgrotuing.
3. **Analysis centrality** and resilience is carried out calculating shortest paths with the inputs weighted and regular origin-destination. While calculating connectivity using the edge betweenness indicator provides results to answer the 1st and 2nd research question, calculating the lack of redundancy with alternative paths provides results to answer the third research question.

Datasets

The table 1 summaries the initial data from which intermediate and final results are derived. The section link includes the origin of the data, so third parties to reuse. In addition, the public github repository with open data license also provide the data of the study.

The total built-up volume weighted the sampling of the origin and destination and is accessible via the following DOI:10.2905/AB2F107A-03CD-47A3-85E5-139D8EC63283. The degree of urbanization determined the urban dense settlement analysed contained the 9 municipalities that comprises the studied area named core metropolitan area and is accessible via the following DOI:10.2905/A0DF7A6F-49DE-46EA-9BDE-563437A6E2BA.Similarly, the subset of the flood is derived from the cheias_rhguaiba_2024_db_v11.gpkg accesible

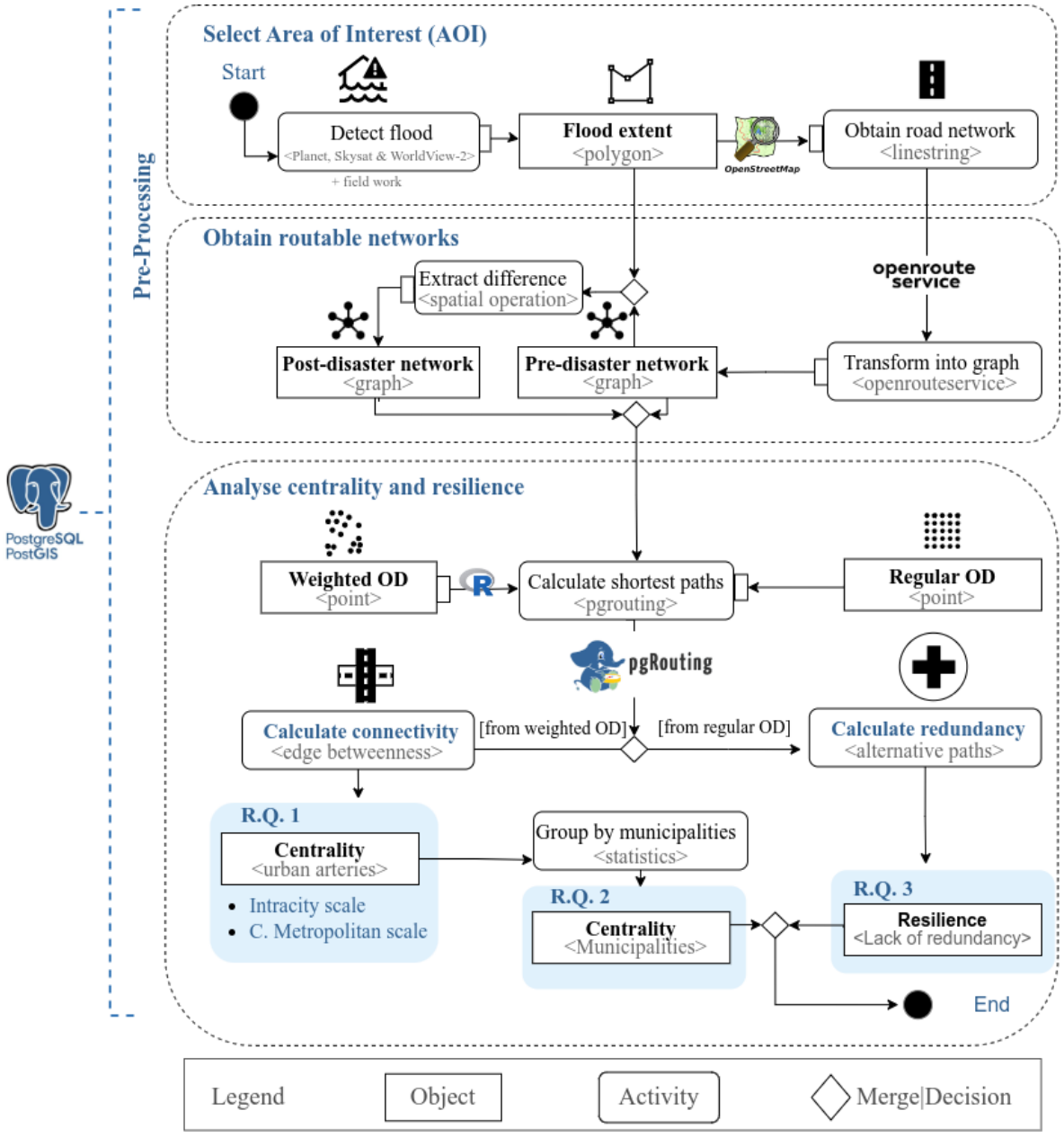

Figure 1: Fig.1 Flowchart

in the DOI:10.5281/zenodo.11164049. For the hospitals, we used the dataset Hospitais_com_Leitos_de_UTIs_no_RS.geojson that included the bed capacity and is accessible via the DOI:10.7303/syn32211006.1. The location of the healthcare facility is obtained using the WFS provided by "Secretaria Estadual da Saúde/DGTI"

Table 1: Table 1: Original raw datasets

Data	Description	Link
GHSL-Built-V	total built-up volume in m^3	GHSL-Built-V
GHSL-SMOD	Degree of Urbanisation	GHSL-SMOD
cheias_rhguaiba_2024_db_v11.gpkg	Flood extent obtained on the 29th April, 2024	Flood extent
ETLCNES_SR_RS_21_12_t.csv	It includes ICU beds of healthcare facilities	Hospital data
Hospitais_com_Leitos_de_UTIs_no_RS.geojson	It includes geolocation of healthcare facilities with ICU	Hospitals
geoBoundaries-BRA-ADM2	It contains subnational administrative boundaries in Brazil	Adminiistrative units
OpenStreetMap data	It represents the road network in the region of Sul, in Brazil	OSM data

Computational workflows

Lane	Activity	Time
Select Area of Interest (AOI)	Flood extent:	Xs
Select Area of Interest (AOI)	Obtain road network	Xs
Obtain routable network	Transform into graph: Convert into graph	Xs
Obtain routable network	Transform into graph: Export geometry	Xs
Obtain routable network	Extract difference: Subset flood extent	Xs
Obtain routable network	Extract difference: Post-disaster network	Xs
Analyse centrality and resilience	Weighted OD	Xs

Lane	Activity	Time
Analyse centrality and resilience	Regular OD	Xs
Analyse centrality and resilience	Calculate connectivity: RQ1: C.Metropolitan scale	Xs
Analyse centrality and resilience	Calculate connectivity: RQ2: Intracity Scale	Xs
Analyse centrality and resilience	Calculate resilience: RQ3: Resilience-lack of redundancy	Xs

Computational environment

- PostgreSQL 15.3 is used from the docker file container that includes the extension PostGIS 16-3.4-v2024.03.17 and pgrouting 3.5.
- The libraries that includes the study analysis, visualization and creation of this documentation is available with the renv file.
- The study required a CPU Intel(R) Core(TM) i5-4300U CPU @ 1.90 GHz with 15 Gi model HP EliteBook 820 G1.
- QGIS Version 3.38 'Grenoble'
- RStudio 2023.06.1+524 "Mountain Hydrangea"
- openrouteservice:v8.0.0 used following the described docker file container instructions

Computation steps

This Quarto book describes the detailed steps carried out for this use case in three chapters that contains the workflow described in the Fig 1 with 8 activities.

Part I

Select AoI

Work in progress, waiting for acceptance.

1 Detect flood

Work in progress, waiting for acceptance.

2 Obtain road network

Work in progress, waiting for acceptance.

Part II

Obtain routable network

Work in progress, waiting for acceptance.

3 Transform into graph

Work in progress, waiting for acceptance.

4 Extract difference

Work in progress, waiting for acceptance.

Part III

Analysis Centrality and Resilience

Work in progress, waiting for acceptance.

5 Origin-Destination matrix

Work in progress, waiting for acceptance.

6 Calculate short path

Work in progress, waiting for acceptance.

7 Calculate connectivity

7.1 RQ1

7.2 RQ2

Work in progress, waiting for acceptance.

8 Calculate redundancy

8.1 RQ3

Work in progress, waiting for acceptance.

References

Belliard, Frederique, Rusne Sileryte, Anita Graser, Karl Broman, Marta Teperek, Carlos Granell, Barbara Hofer, et al. 2019. "AGILE Reproducible Paper Guidelines." https://doi.org/10.17605/OSF.IO/CB7Z8.