

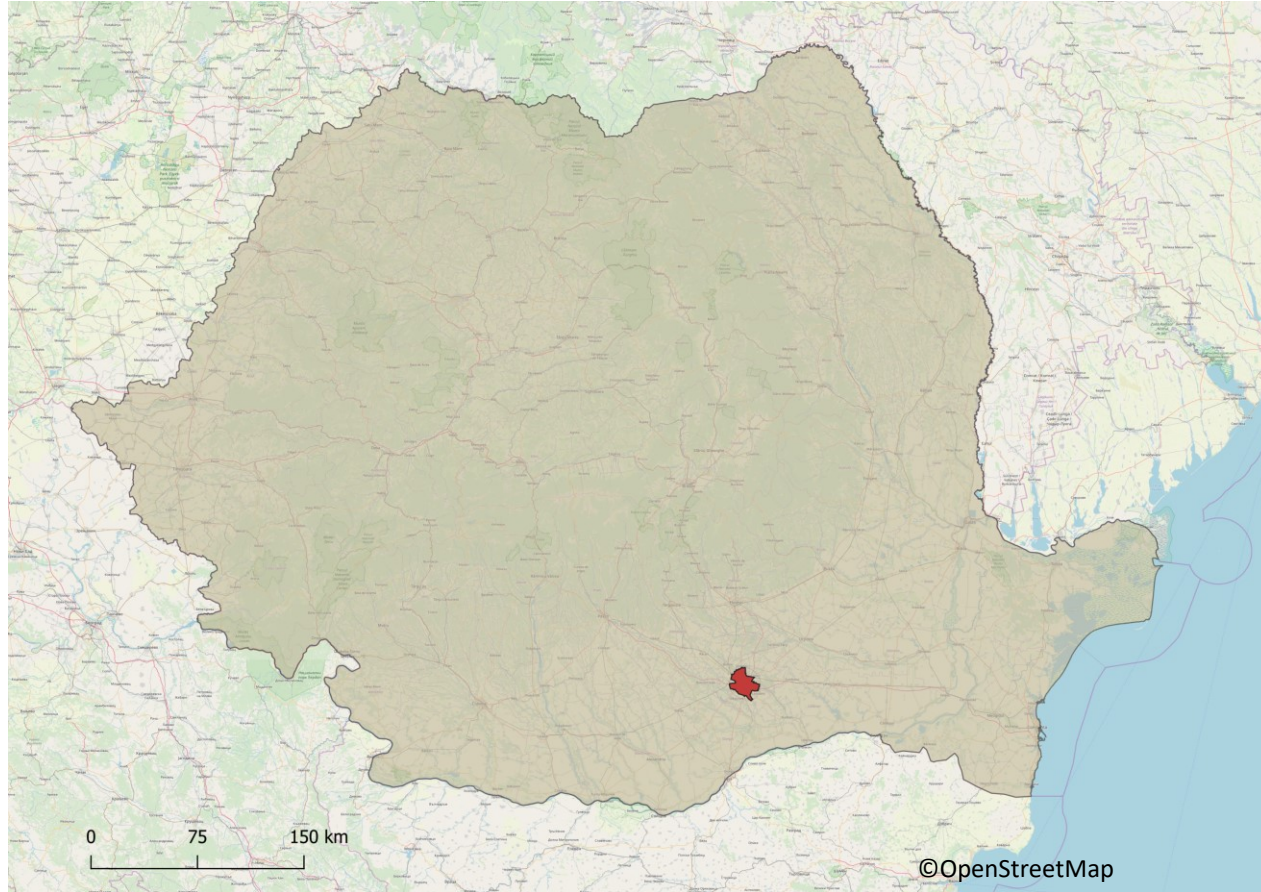
Emergency shelter selection in the context of seismic risk. Case study – Bucharest, Romania

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Objectives

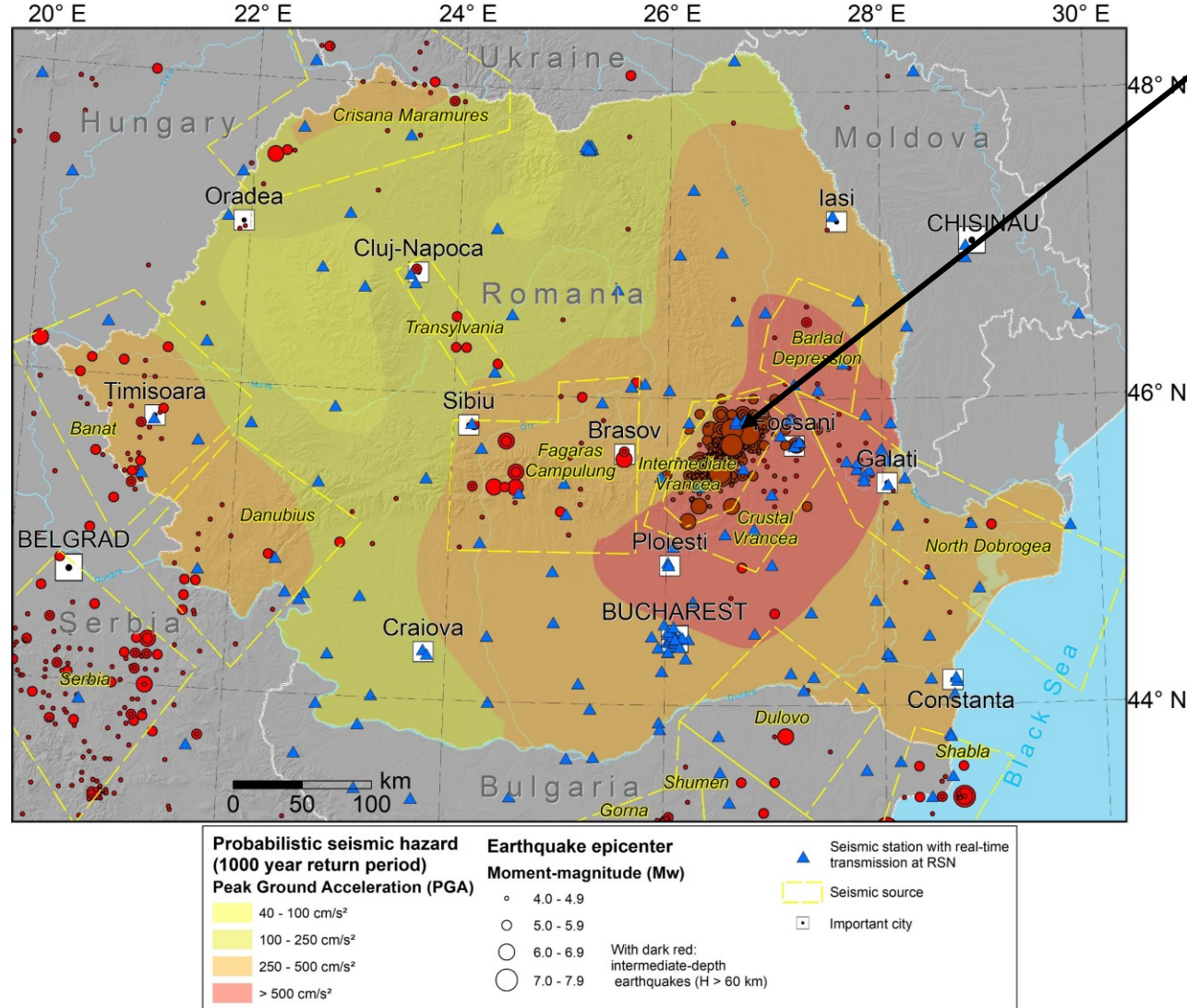
- First attempt
- Identify suitable areas for installing first aid centres in case of a major disaster
- Increase the preparedness of the authorities

The study area



- In South-Est of Romania
- The capital
- 2+ mil. Inhabitants
- Many buildings are old and damaged

The seismic risk



(Toma-Danila et al., 2018)

- Highly exposed to Vrancea earthquakes
 - intermediate-depth earthquakes with moment-magnitudes (Mw) of up to 8.1 occur, at a statistical rate of 2–3 events with Mw>7 per century
- High population density
- Many old and vulnerable buildings to earthquakes:
 - > 31430 residential buildings constructed prior to 1946 (pre-code period), 294 having more than 4 storeys - a vulnerable category due to long fundamental periods of intermediate-depth Vrancea earthquakes (2011 census data)

→ The most vulnerable European capital to earthquakes

- Bucharest city was affected by several intense earthquakes – e.g.:
 - 1802 (Mw aprox. 7.9)
 - 1838 (Mw 7.5)
 - 1940 (Mw 7.4): 300 – 500 deaths and 183 affected buildings
 - 1977 (Mw 7.2): 1.400 deaths and 33 collapsed buildings
 - Next - ???
- In a case of a severe earthquake, the emergency hospitals could not deal with the high number of victims
- Some areas might be isolated due to debris, so local first-aid centers are needed

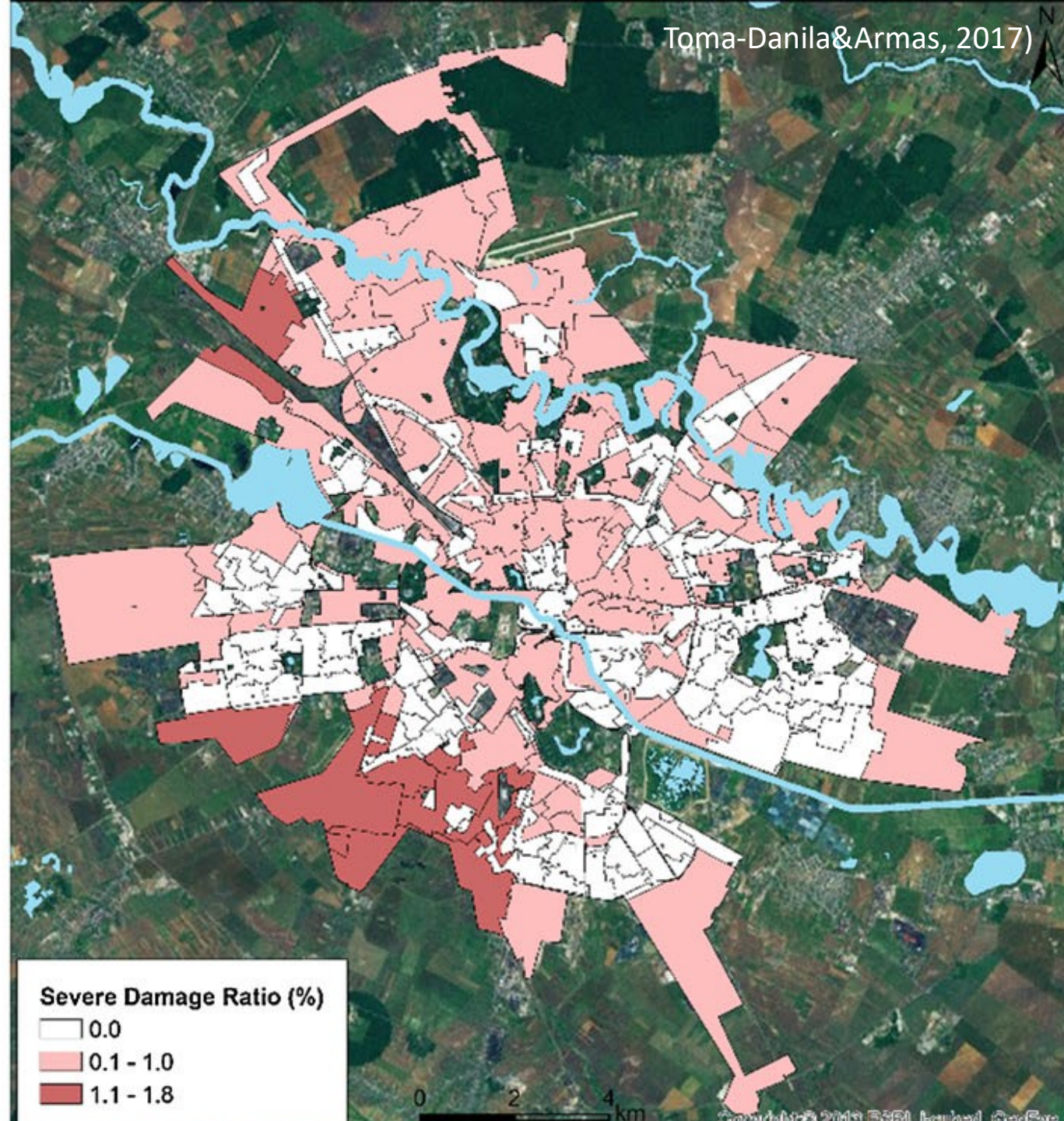
Data

- 2011 census data
 - OSM data
 - Vectors derived from orthophotoplans, city plans
 - Interviews with fire fighters
-
- ILWIS Software

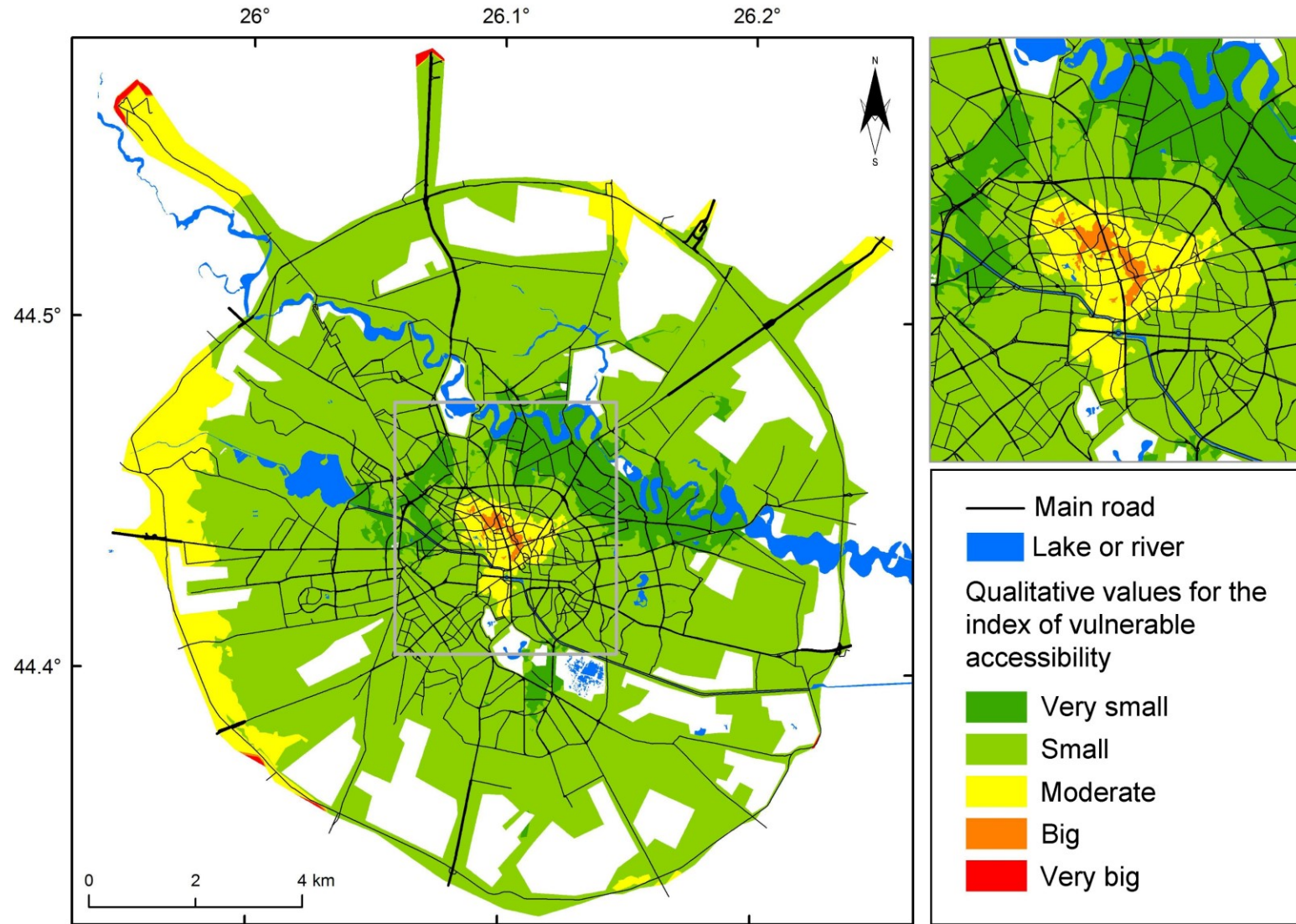
The analysis

- **Physical vulnerability** (Toma-Danila&Armas, 2017, using SeisDaRo System)
 - Construction period
 - Height
 - Construction materials
 - Capacity and fragility functions

→ The higher the physical vulnerability, the higher the probability of more victims

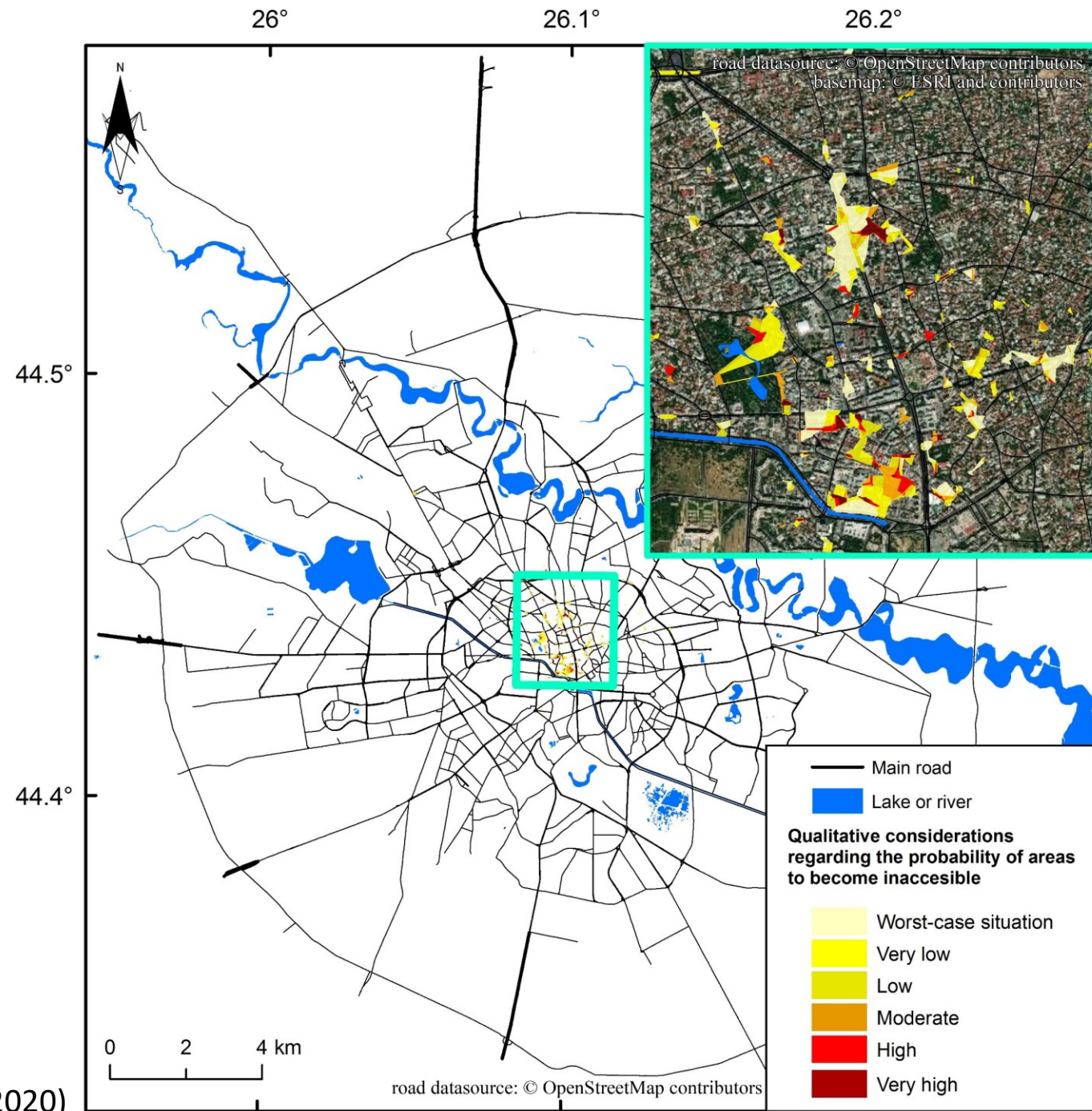


- **Accessibility** (Toma-Danila et al., 2020)
- Road accessibility – the difficulty to reach specific areas by emergency intervention forces
- Location of emergency hospitals
- Location of fire stations
- Different traffic conditions (night time, 8 AM Monday and 6 PM Monday typical conditions)



(Toma-Danila, 2020)

- **Distance from the obstructed areas** (Toma-Danila, 2020)
- The official list of the buildings that are in the I class of seismic risk
- These buildings are very likely to collapse at a stronger earthquake



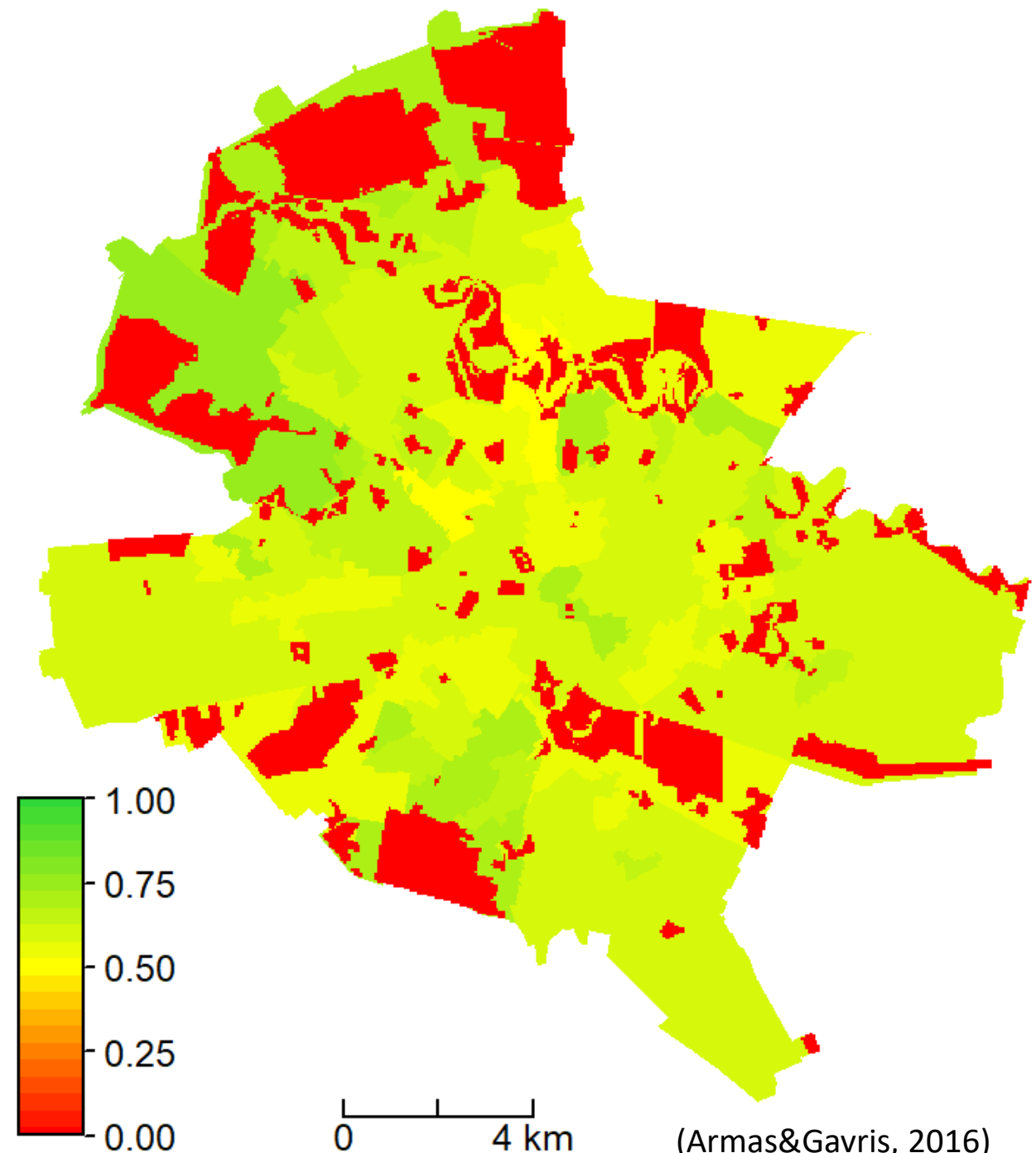
(Toma-Danila, 2020)

- **Socio-economic vulnerability**

(Armas&Gavris, 2016, on 2011 Census data)

- Social (dwelling density; widows; elderly; room occupancy per household; females)
- Education (minimum education, unemployed, more than 3 children)
- Housing (housing density; room area/person, household room area; private big households)
- Social dependence (dependent people; children)

→ The higher the social vulnerability, the greater the need for first aid centres



- **Other factors – distance from:**

- Fuel stations
- Pharmacies
- Main hospitals
- Other health units (private hospitals, small hospitals, specialized etc.)
- Fire-fighter units

- **Locations – distance from:**

- Indoor (schools and churches)
- Outdoor (parks, parking lots – supermarket, public, private etc.; both over 1.000 sqm)

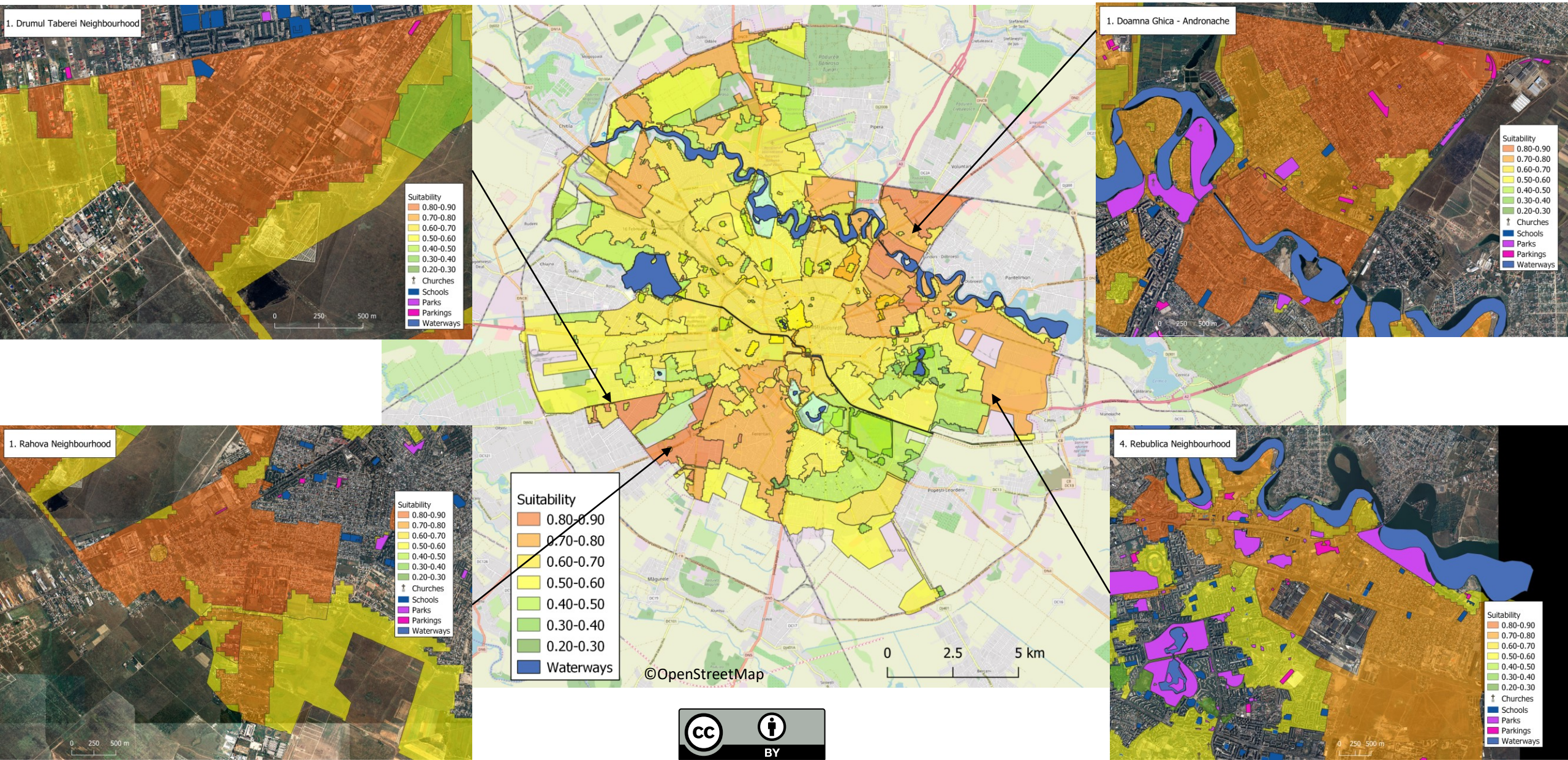
Methodology – standardization

No.	Criteria	Factor	Standardization method
1	Socio-economic vulnerability	Benefit	Maximum
2	Physical vulnerability	Benefit	Maximum
3	Accesibility	Cost	Maximum
4	Distance from the obstructed areas	Benefit	Maximum
5	Other factors		
5.1	Distance from fuel stations	Combination	Combination – 500 – 1500
5.2	Distance from pharmacies	Cost	Maximum
5.3	Distance from main hospitals	Cost	Maximum
5.4	Distance from other health care units	Cost	Maximum
5.5	Distance from fire-fighters units	Cost	Maximum
6	Locations		
6.1	Indoor		
6.1.1	Distance from kindergartens	Cost	Maximum
6.1.2	Distance from gymnasiums	Cost	Maximum
6.1.3	Distance from highschools	Cost	Maximum
6.1.2	Distance from churches	Cost	Maximum
6.2.	Outdoor		
6.2.1	Distance from parks	Cost	Maximum
6.2.2	Distance from parking lots	Cost	Maximum

Methodology – weighting (Expert judgement)

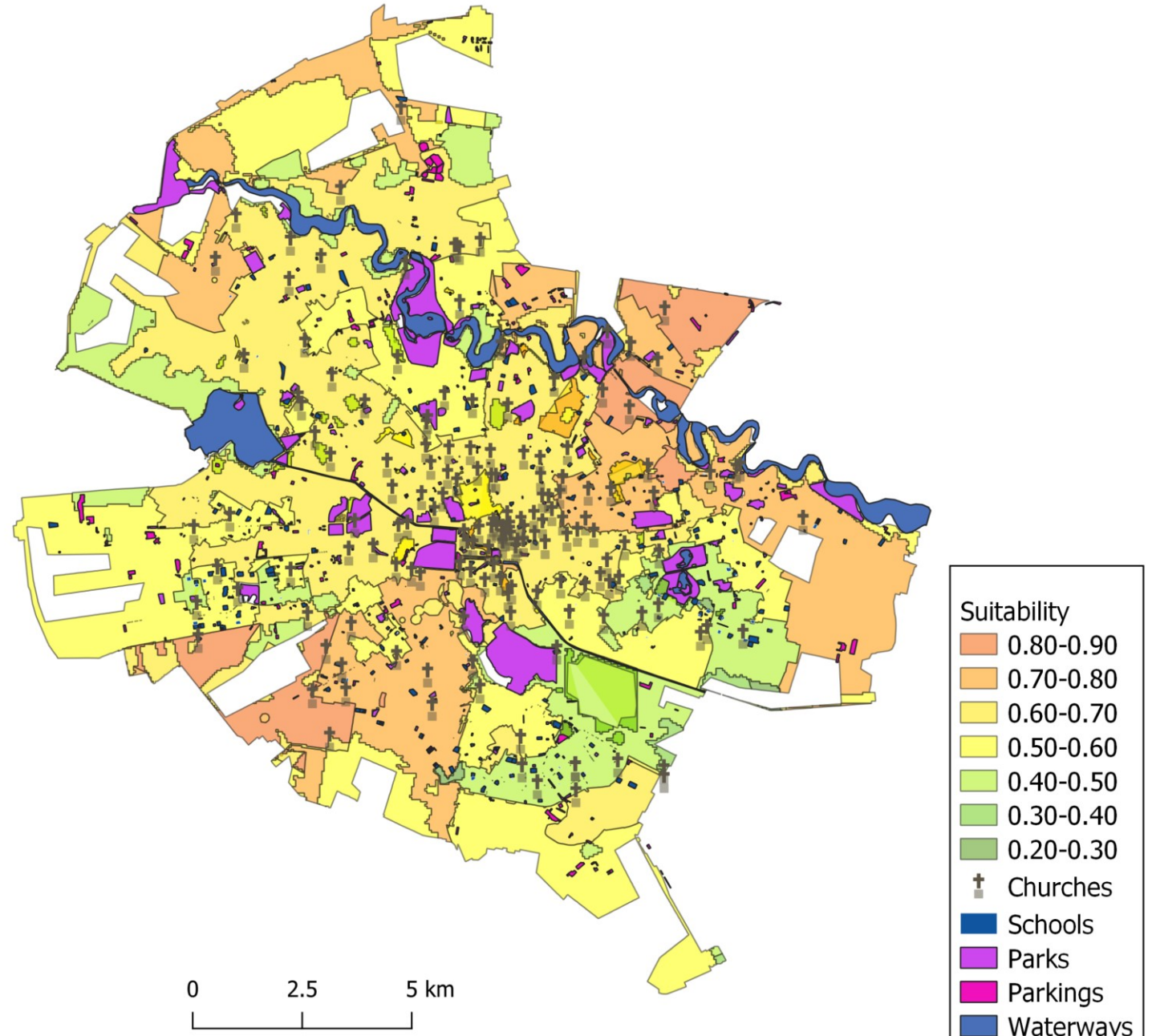
No.	Criteria	Weigh	Weighting method
1	Socio-economic vulnerability	0.214	Rank Sum
2	Physical vulnerability	0.286	
3	Accesibility	0.095	
4	Distance from the obstructed areas	0.143	
5	Other factors	0.214	Rank Sum
5.1	Distance from fuel stations	0.067	
5.2	Distance from pharmacies	0.133	
5.3	Distance from main hospitals	0.300	
5.4	Distance from other health care units	0.200	
5.5	Distance from fire-fighters units	0.300	
6	Locations	0.048	Pairwise
6.1	Indoor	0.75	Rank Sum
6.1.1	Distance from kindergartens	0.15	
6.1.2	Distance from gymnasiums	0.40	
6.1.3	Distance from highschoools	0.40	
6.1.4	Distance from churches	0.06	
6.2.	Outdoor	0.25	Rank Sum
6.2.1	Distance from parks	0.500	
6.2.2	Distance from parking lots	0.500	

Results – areas with a higher need of first-aid centers



Results - potential first-aid centres locations

- Areas with a higher need for FAC, but with no alternatives
- Areas with a lower need for FAC, but with many alternatives



Next...

- In-depth analysis
- Identify the characteristics needed in order for a space to become a first-aid centre
- Correlate the number and the dimensions of the potential places with the people that inhabit that area
- Establish the exact locations of the first-aid centres for each neighbourhood

Conclusions

- Several areas that are suited (in need) for locating first-aid centres have been identified
- The number of possible alternatives for locating the first-aid centres are very different within each suitable area
- Further investigation has to be done

References

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