Transportation Network Spatial Analysis to Measure Pedestrian Suitability. The Case of Hilly Cities

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1. Introduction

- ✓ The current climate and environmental emergency, together with the growing traffic congestion and pollution in urban areas, make mobility and its sustainability a priority in current transport policies.
- ✓ It is necessary to provide feasible alternatives to private cars, namely through the offer of high-quality pedestrian infrastructures, adapted to the cities' specific characteristics and their citizen's needs. These aspects are particularly important in ***hilly cities, where traveling by foot requires an additional effort.***
- ✓ **AIM OF THE STUDY:** to contribute to the promotion of soft mobility in hilly cities by creating a ***support instrument to assess the suitability of existing pedestrian infrastructures***.

2. Urban mobility strategies in the EU

In 2016, ***urban transport was responsible for 23% of EU's greenhouse gas emissions*** (European Commission, 2016).

Chronic congestion, with consequences in terms of traffic delay and pollution represents an estimated annual cost of ***80 billion euros*** for the economy of many European cities (European Commission, 2013).

This evidence supports the need for cities to undertake a major effort to reverse the observed trend and contribute to achieve the objective of a ***60% reduction in greenhouse gas emissions announced by the EU Commission in its White Book*** (European Commission, 2013).

2. Urban mobility strategies in the EU

European policies and strategies

✓The Green Paper (2007)

✓The Action Plan on Urban Mobility (2009)

✓The Europe 2020 Strategy (2010)

✓The White Paper (2011)

✓The European Strategy for Low-Emission Mobility (2016)

✓The Pact of Amsterdam (2016)

✓The Graz Declaration (2018)

The implementation of these strategies and policies can presently be witnessed, justifying the development of technical and scientific tools essentials to support mobility interventions in urban areas.

2. Urban mobility strategies in the EU

Portuguese projects, plans and documents

- ✓The Sustainable Mobility Project (2010)
- ✓The Mobility Package (2012)
- ✓The Bicycle and other Soft Modes Promotion Plan (2012)
- ✓The Strategic Transport and Infrastructure Plan 2014-2020 (2015)
- ✓The Green Growth Commitment (2015)
- ✓The National Strategy for Active Pedestrian Mobility 2020-2030 (under development)

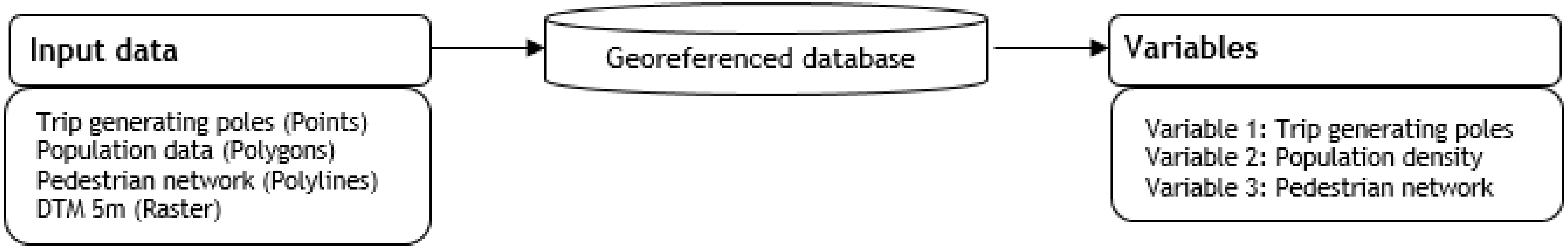
Specific guidelines contemplating the orography factor are not considered in European and Portuguese urban mobility strategies & policies!

3. Methodology for assessing the pedestrian infrastructure suitability in hilly cities

The proposed methodology is based on the consideration of a set of variables that are ***spatially analyzed and combined using a multicriteria approach applied in a GIS environment***

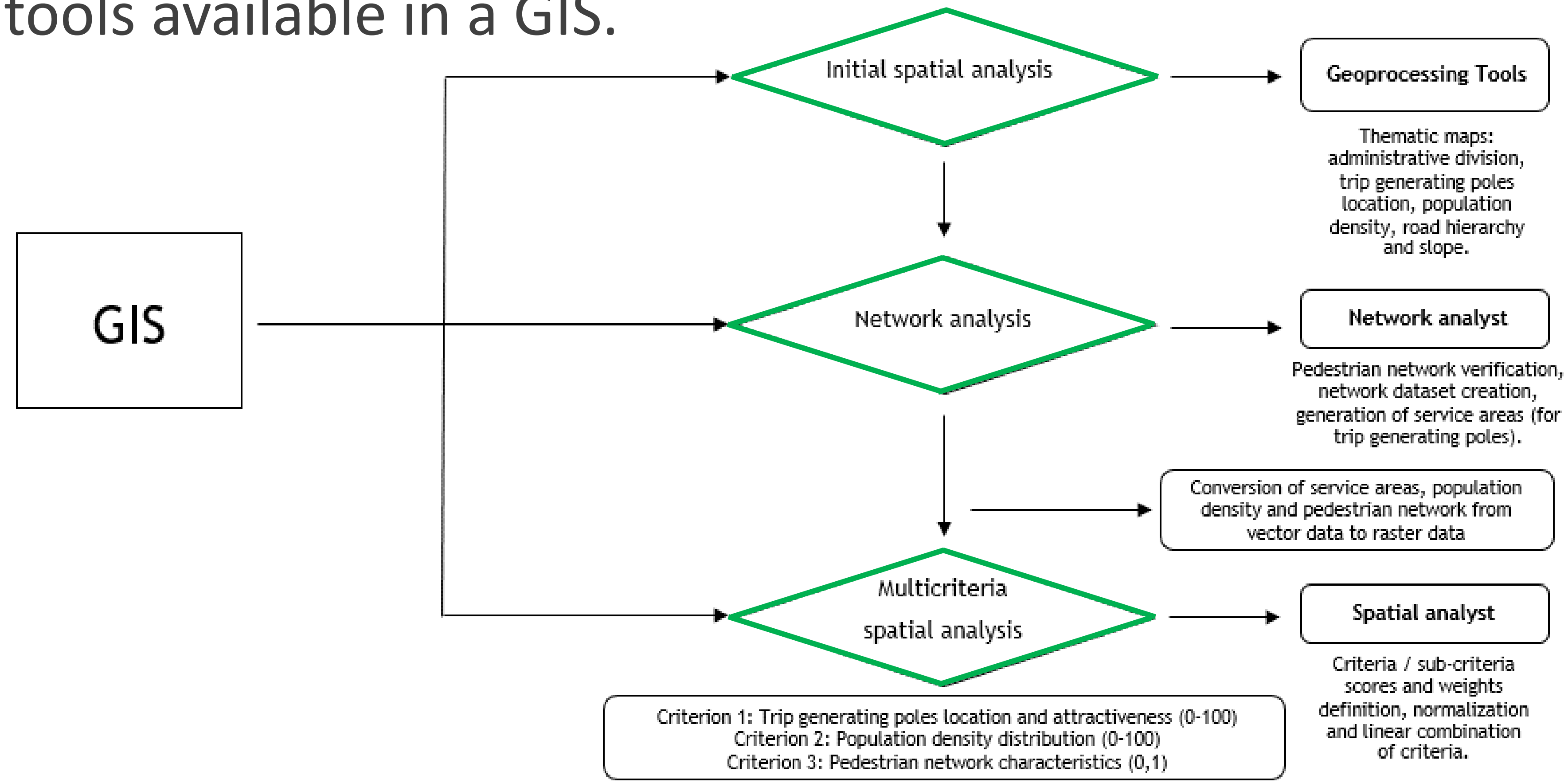
Three methodological stages are considered:

1. The data collection and organization and the variables selection are performed in the first stage.



3. Methodology for assessing the pedestrian infrastructure suitability in hilly cities

2. Second stage comprises spatial analyses carried out using the tools available in a GIS.



3. Methodology for assessing the pedestrian infrastructure suitability in hilly cities

3. The model calibration and outcomes analysis are done in the third stage.

Legend

PS is the pedestrian suitability of the network segments (0-100)

$$PS = (p_{TGP} \times TGP_n + p_{PD} \times PD_n) \times PNS$$

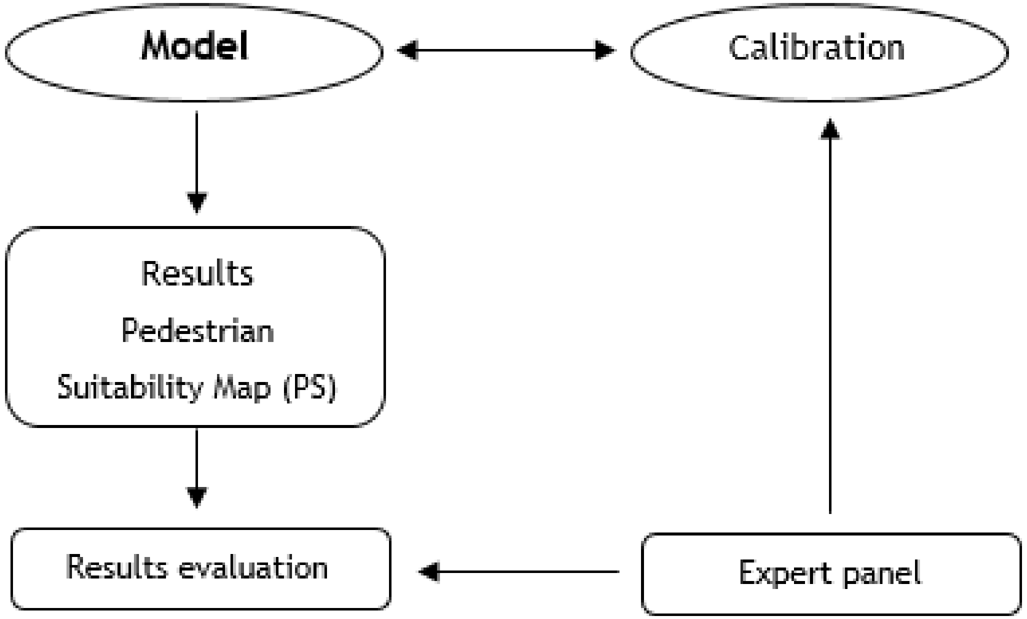
p_{TGP} is the trip generating poles criterion weight

TGP_n is the trip generating poles criterion value (normalized)

p_{PD} is the population density criterion weight

PD_n is the population density criterion value (normalized)

PNS is the pedestrian network segment value (0 or 1)



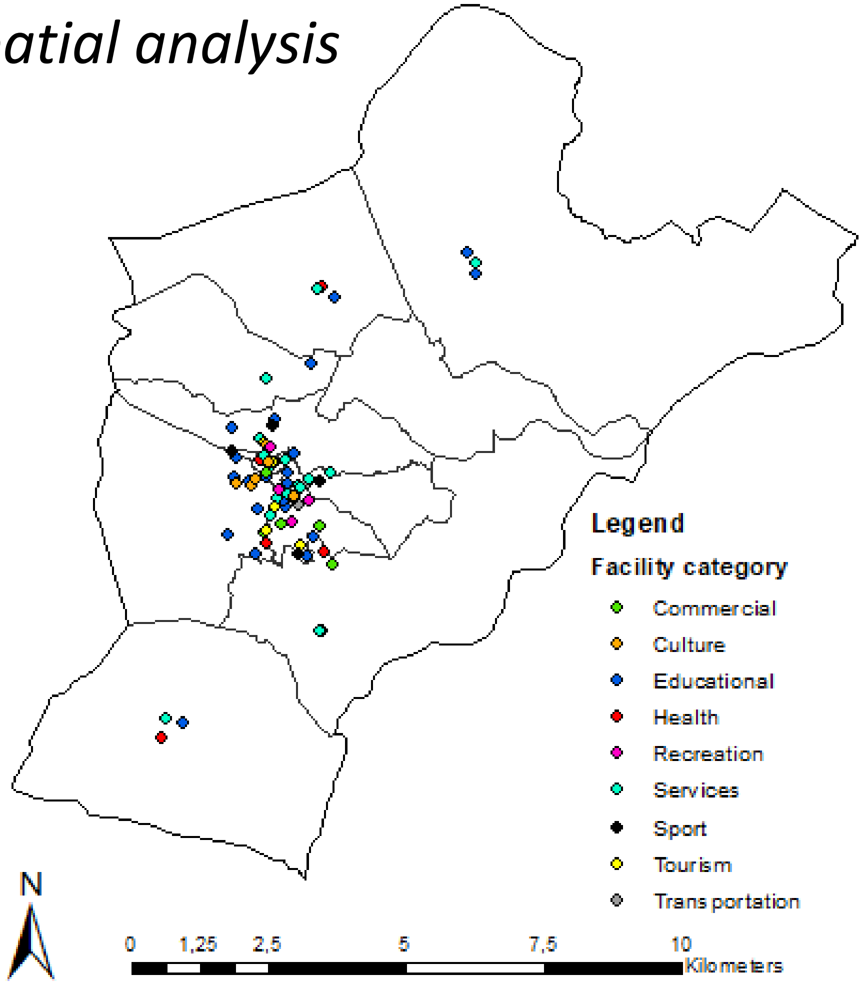
4. Case study

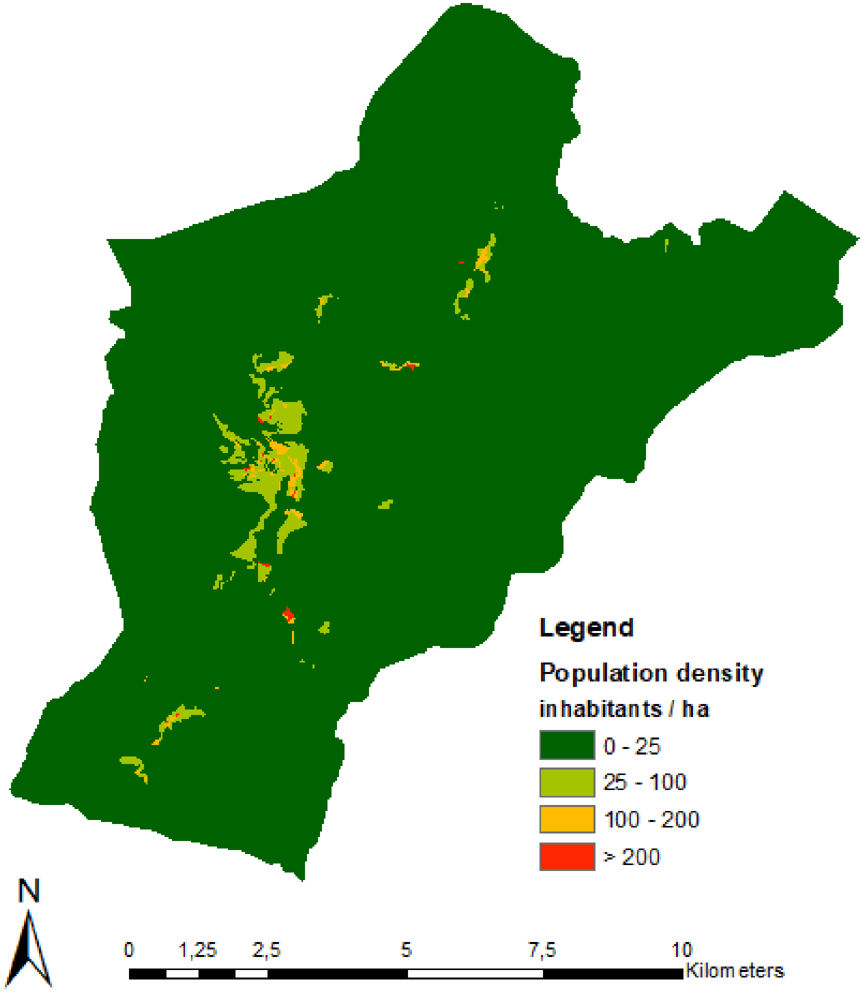
Municipality of Covilhã

- ✓ Central region of Portugal
- ✓ District of Castelo Branco, on the eastern slope of Serra da Estrela
- ✓ 21 civil parishes (5 located within the ***urban perimeter***)
- ✓ Total area ≈ 550 km²
- ✓ Population ≈ 51800 resident
- ✓ Road network ≈ 1851 km
- ✓ Urban perimeter road network ≈ 450 km

4. Case study

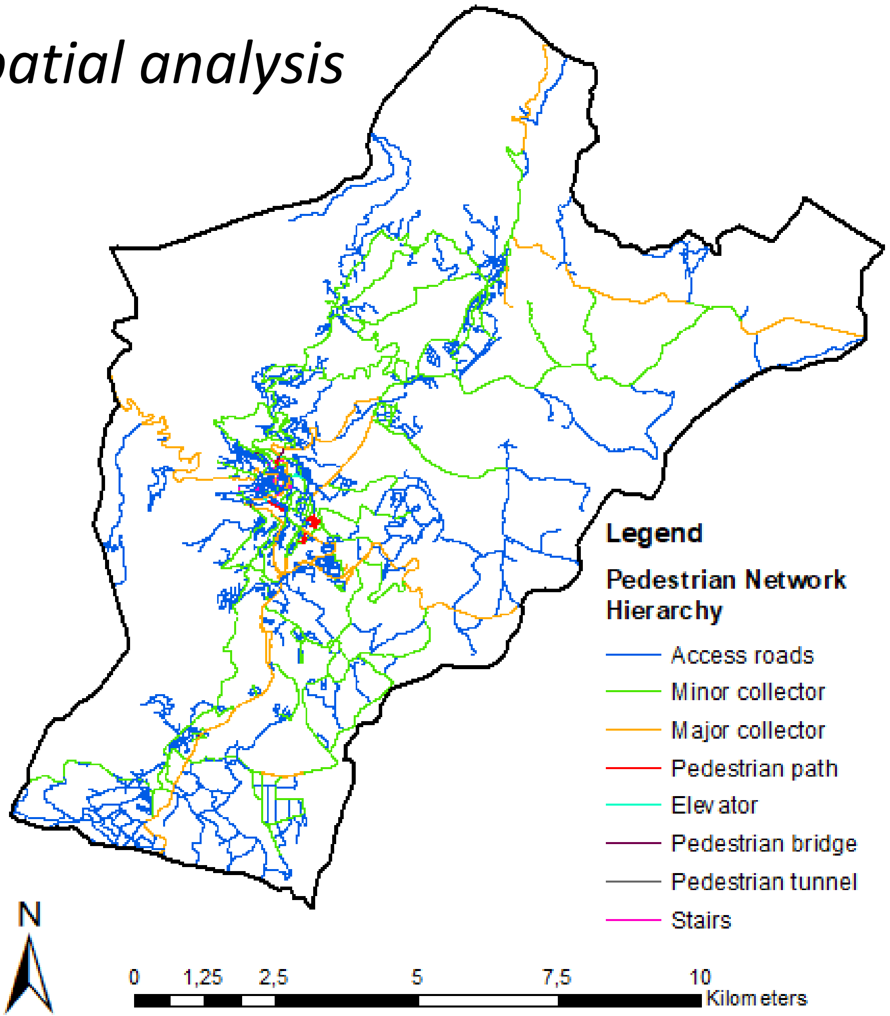
Initial spatial analysis

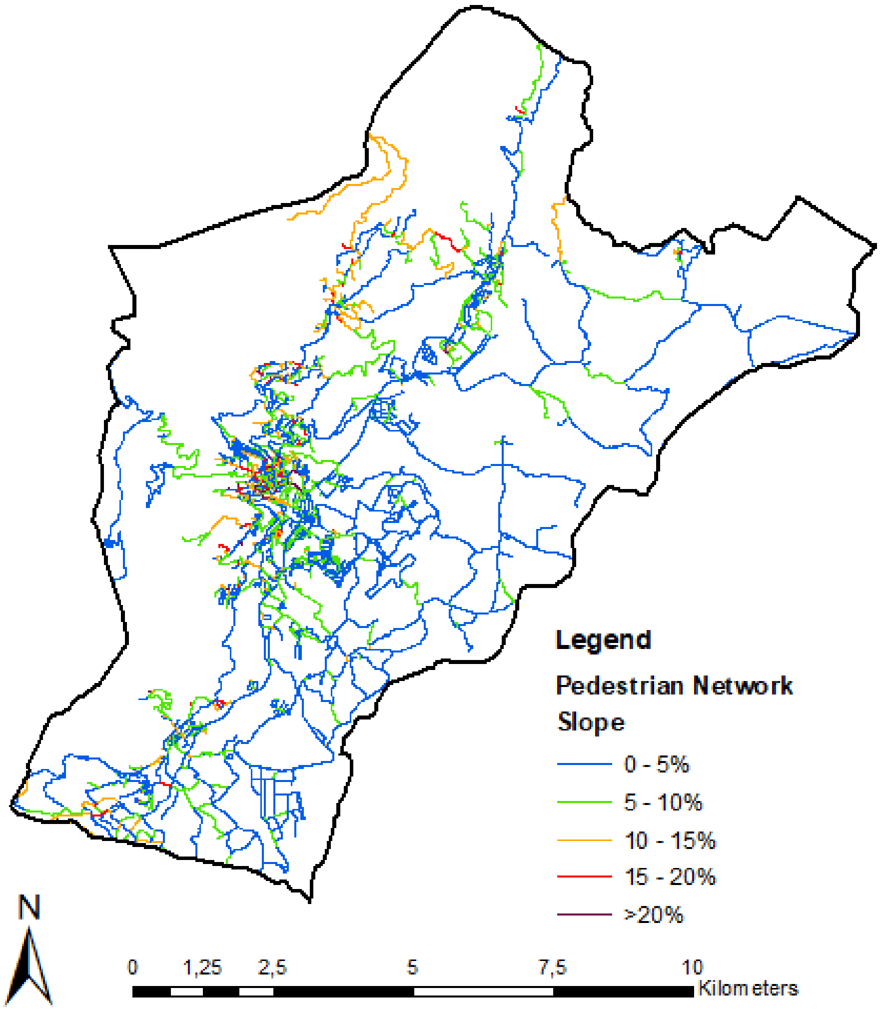




4. Case study

Initial spatial analysis

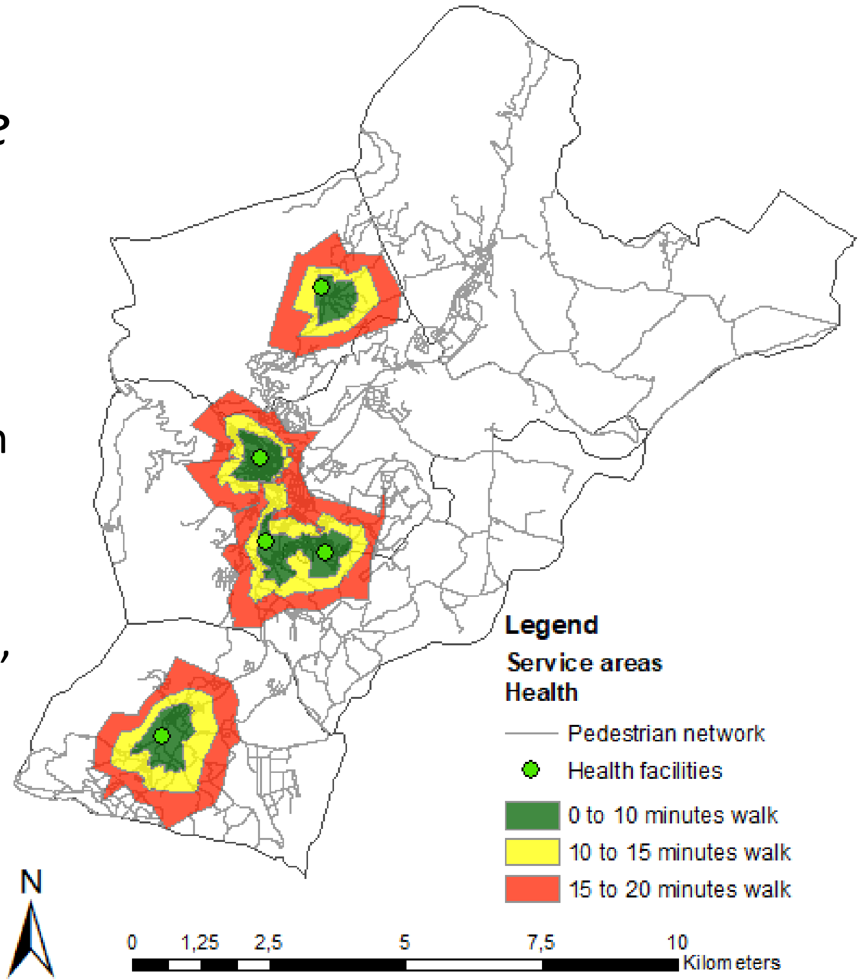


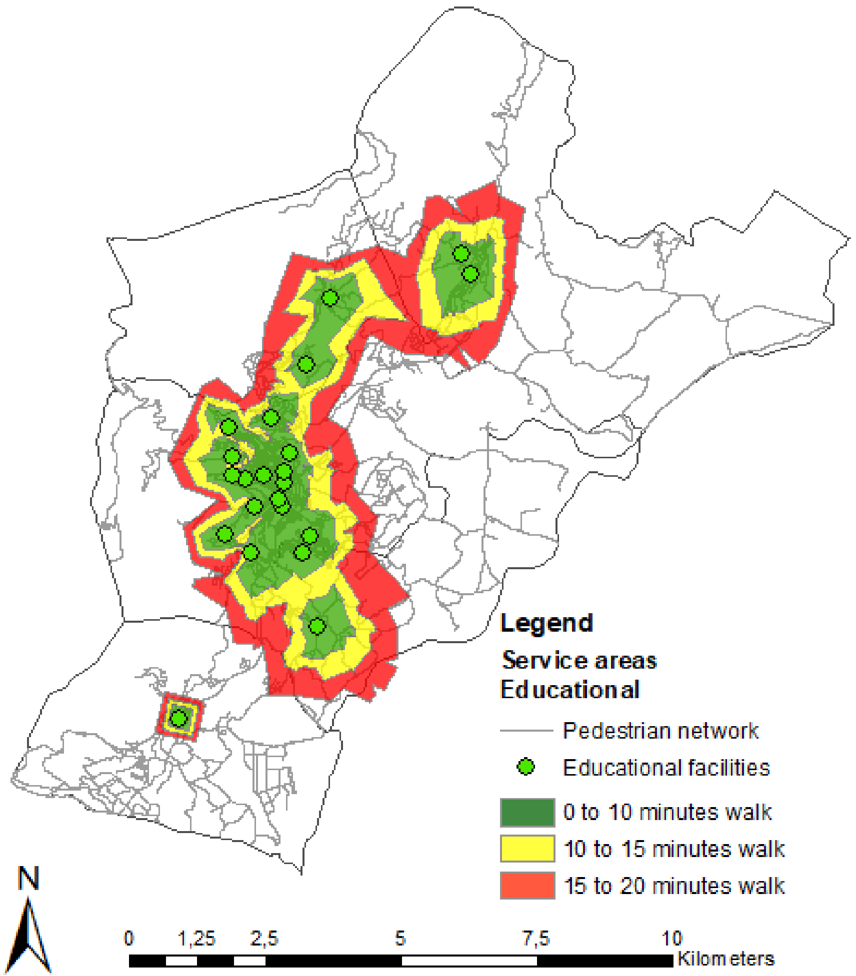


4. Case study

Network analysis Pedestrian service areas maps

Travel distance was computed using the Tobler's Hiking Function model considering the road/path slope, pedestrian speeds at stairs and city elevators' and funiculars' speed (vertical and oblique connections).





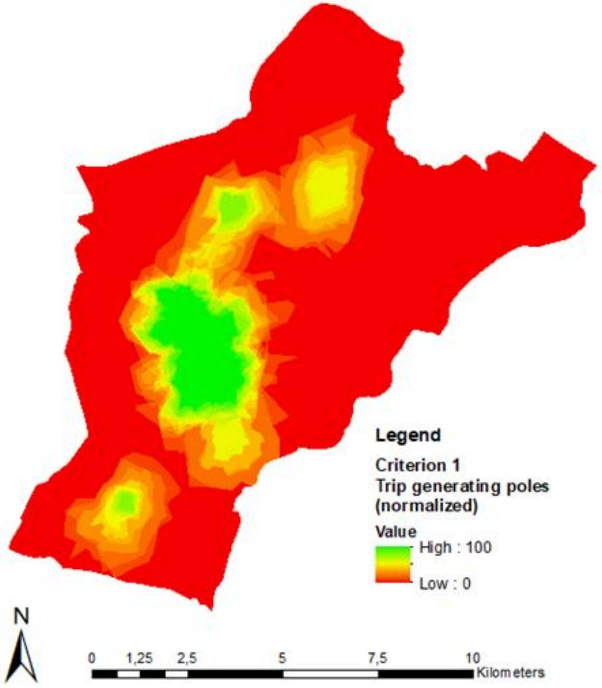
4. Case study

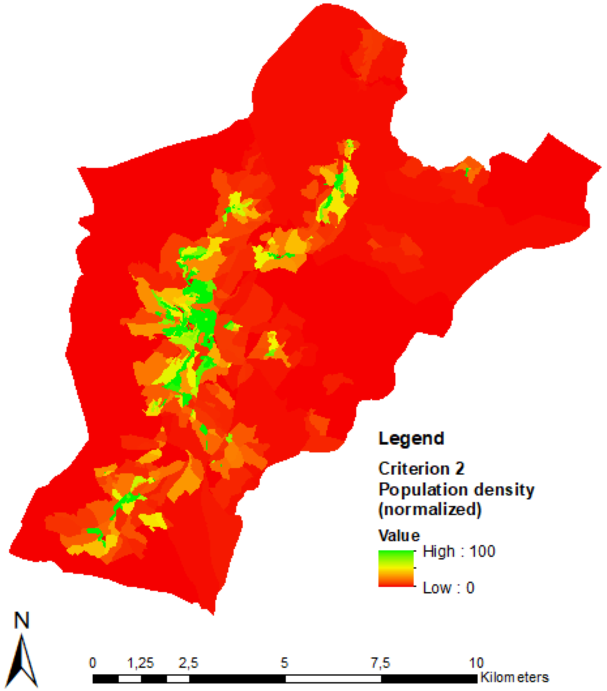
Multi-criteria analysis

$$TGP = \sum_{i}^{n} \frac{w_n \times i_n}{n}$$ (combined score for trip generating poles - TGP)

Travel time (min)	Score (0-100)	Facility category	Weight
0 – 10	90	Transportation	0.71
10 – 15	60	Health	0.68
15 - 20	30	Educational	0.75
> 20	1	Services	0.62
		Commercial	0.63
		Tourism	0.60
		Culture	0.54
		Recreation	0.65
		Sport	0.58

$$x_i = \frac{(R_i - R_{min})}{(R_{max} - R_{min})} \times 100$$ (normalization of values to a 0-100 scale)





4. Case study

Results

Pedestrian suitability map

$$PS = (p_{TPG} \times TPG_n + p_{PD} \times PD_n) \times PNS$$

Pedestrian suitability (PS)

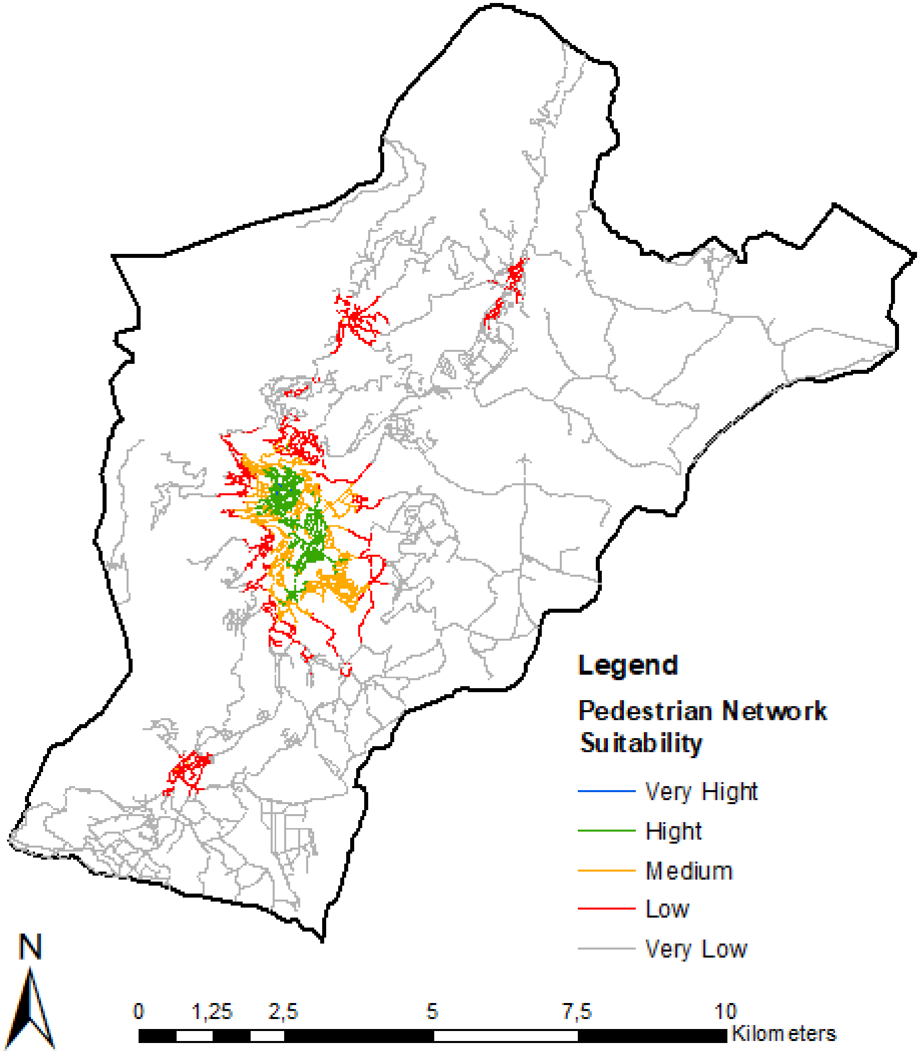
very high (80<PS≤100)

high (60<PS≤80)

medium (40<PS≤60)

low (20<PS≤40)

very low (0<PS≤20)



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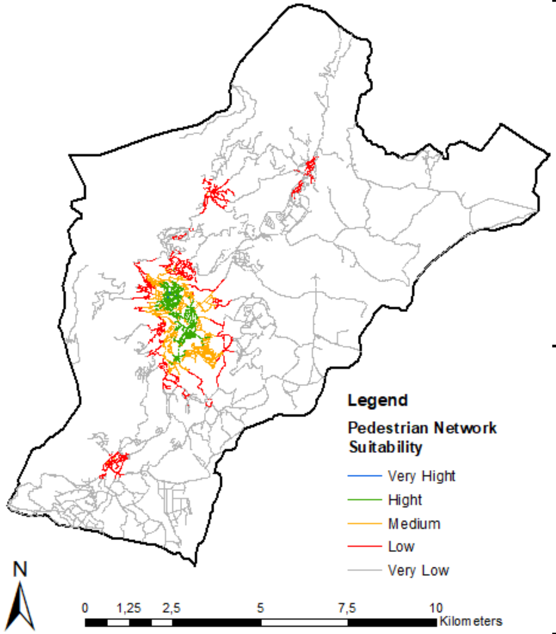
Results



Suitability	Analysis 1 70% TGP_n and 30% PD_n		Analysis 2 60% TGP_n and 40% PD_n		Analysis 3 50% TGP_n and 50% PD_n	
	Pedestrian network length (km)	**Pedestrian network length (%)**	Pedestrian network length (km)	Pedestrian network length (%)	Pedestrian network length (km)	Pedestrian network length (%)
Very high	**0,29**	**0,06**	0,18	0,04	0,08	0,02
High	**41,42**	**9,21**	10,62	2,36	1,96	0,43
Medium	**58,07**	**12,91**	76,29	16,96	60,15	13,37
Low	**60,95**	**13,55**	63,23	14,05	78,77	17,51
Very low	**289,17**	**64,27**	299,58	66,59	308,94	68,67

5. Conclusions

- ✓From the end of the first decade of the 2000s, the EU paid particular attention to sustainable mobility - policies and strategies, as well as the emergence of air quality legislation establishing greenhouse gas emission limits, providing the state members with guidelines for the practice of a better urban mobility.
- ✓Portugal has already started to transpose these policies to the national scene. ***However, although soft modes are beginning to gain expression, the private car continues to be the most used transport mode in Portuguese cities.***

5. Conclusions

- ✓This study contributes to the promotion of soft mobility through the creation of an instrument to assess pedestrian suitability of existing pedestrian infrastructures, considering the orography factor.
- ✓The proposed methodology was validated through its application to a case study, the hilly city of Covilhã. The multicriteria analysis was performed for 3 combinations of TGPn and PDn weights, resulting in three network pedestrian suitability maps that help locate pedestrian networks needs.
- ✓The city centre areas, where most of the population and trip generating poles are concentrated, have a pedestrian network suitability level between medium and very high.

5. Conclusions

- ✓ Peripheral areas of the city, with less effect of the TGP criterion and less population density, have low or very low suitability.
- ✓ It was also possible to identify the expansion areas of the city. These areas currently have good pedestrian network suitability but still relatively low population densities.
- ✓ Future work: complete the information on the pedestrian network with data on the existence and width of sidewalks, the existence and location of pedestrian crossings, conditions for pedestrians with reduced mobility and assessment of the pedestrian level of service.

THANK YOU FOR YOUR ATTENTION!

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