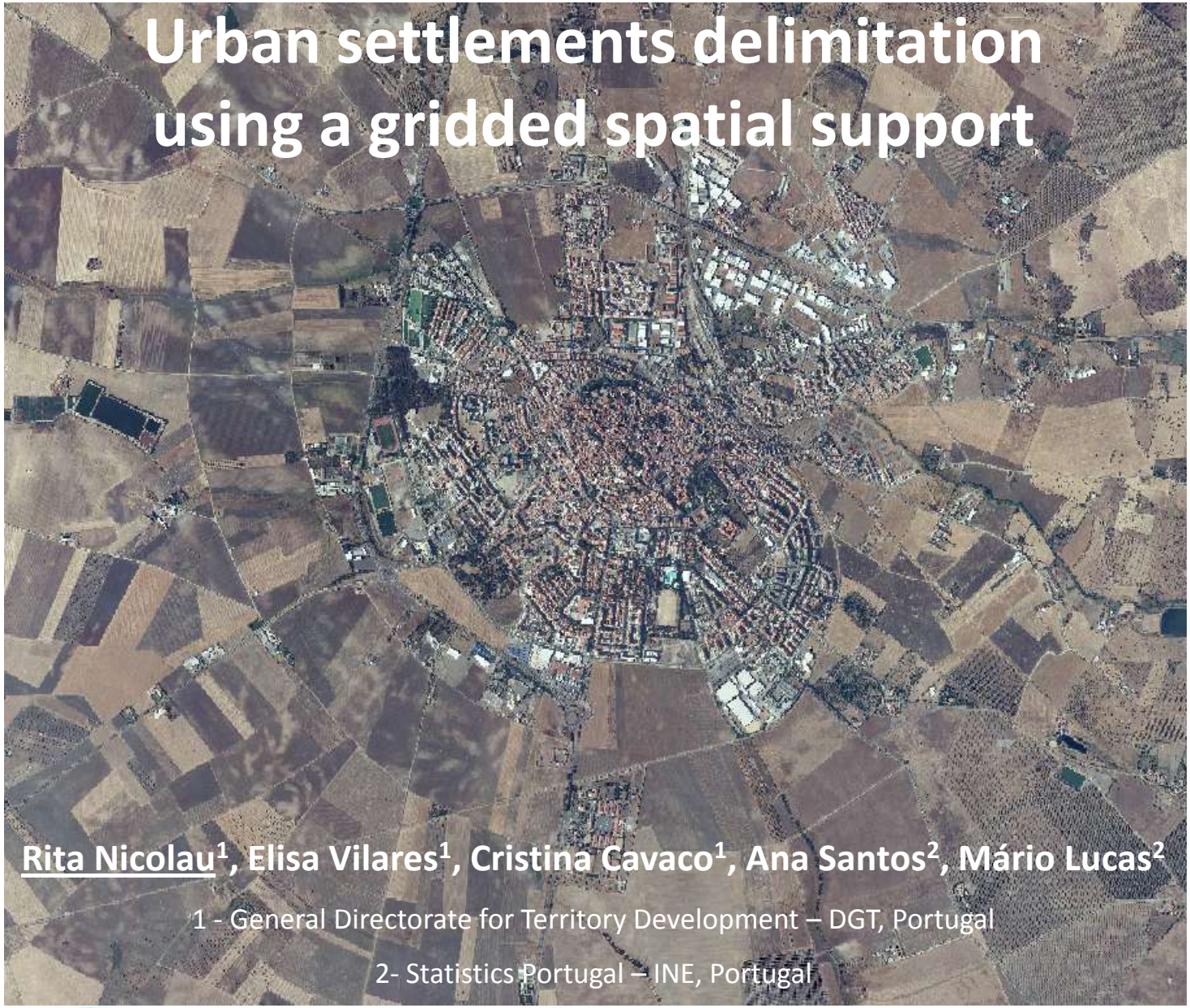
Urban settlements delimitation using a gridded spatial support



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Introduction

In 2011 the OECD and the European Commission (OECD-EC) adopted a new approach for classifying urban areas and an harmonized definition of a city and its commuting zone. OECD-EC definition relies on the spatial allocation of population to 1 Km^2 grid cells and leaves out cities below 50 000 inhabitants (small and medium sized towns).

TOWN (ESPON project) searched for an harmonized definition of such cities/towns and proposed a method based on morphological criteria for their identification.

According to TOWN, urban settlements are clusters of 1 Km^2 grid cells with specific population thresholds.

As the settlement size becomes smaller the TOWN's method becomes problematic.

TOWN's team suggests that the allocation of population to higher resolution grid cells and the integration of land cover data may improve settlements' identification.

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Introduction

Since none of the mentioned approaches is suitable to study the Portuguese urban system, which is mostly composed by small sized towns, we developed an alternative approach adjusted to our context.

Given that municipalities are primarily responsible for urban planning in Portugal, the boundaries of urban settlements usually correspond to the urban perimeters defined in the framework of municipal master plans. Thus, each municipality defines the boundaries of the urban settlements under its administration, following an approach that presently differs among municipalities.

Objectives

- Describe an approach that allows:
  - A computerized delimitation of urban settlements;
  - An harmonized identification of urban settlements;
  - The identification of settlements in urban systems where very small sized towns prevail;
  - The integration of several data sources (census data, land cover data, land use classification, …)
- Test its application to mainland Portugal.
- Evaluate the proposed approach using different spatial supports.

Methods

The approach for identifying urban settlements was implemented in GIS using vector analysis.

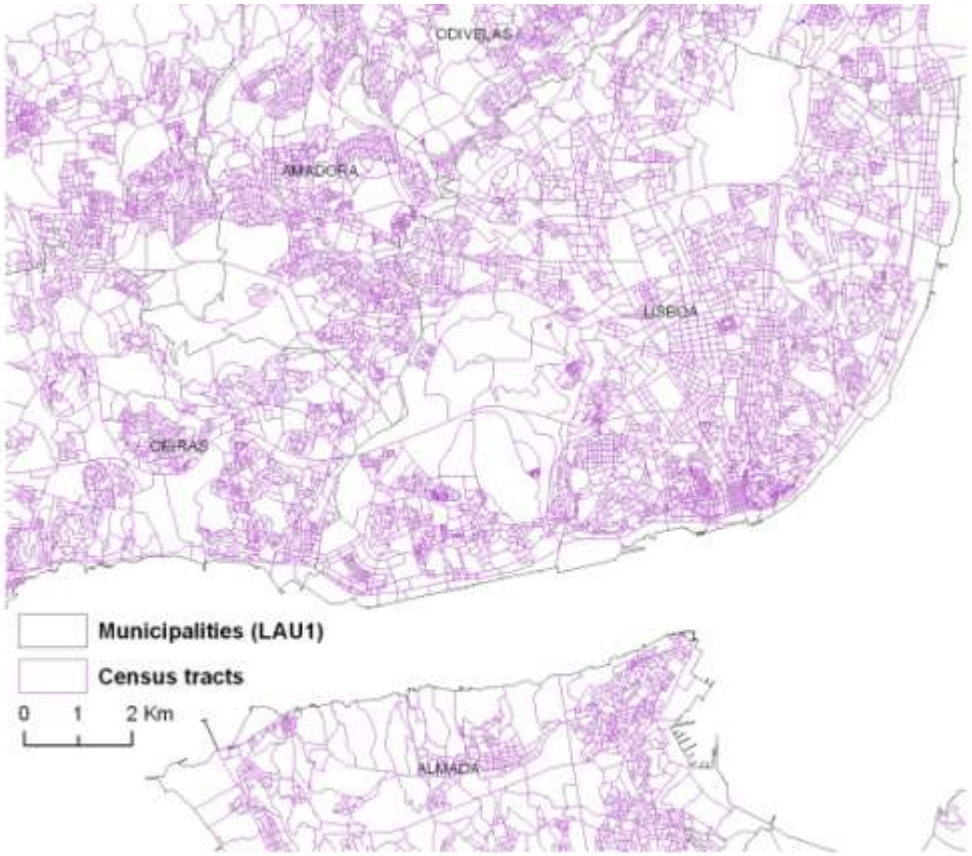
Data Sources	Theme	Datasets
COS 2007 Land cover / Land use map in vector format, with a nomenclature of 193 classes and a minimum mapping unit (MMU) of 1 ha.	Land Cover	Artificial surfaces, with exclusion of mine and dump sites
CRUS 2011 Land use, as classified by Master Plans, in a vector format map.	Planned Land Use	Urban and urbanized areas
CAOP 2011 Official map representing administrative units in vector format.	Administrative units	Municipalities; Location of municipal headquarters
CENSUS 2011	Elementary spatial units geometric definition of spatial units	Census tracts; 250x250 m^2 grid cells
	Census variables	Number of residents and buildings and respective densities per spatial unit
	Spatial units hierarchy	Membership of elementary spatial units with spatial units of hierarchically higher levels

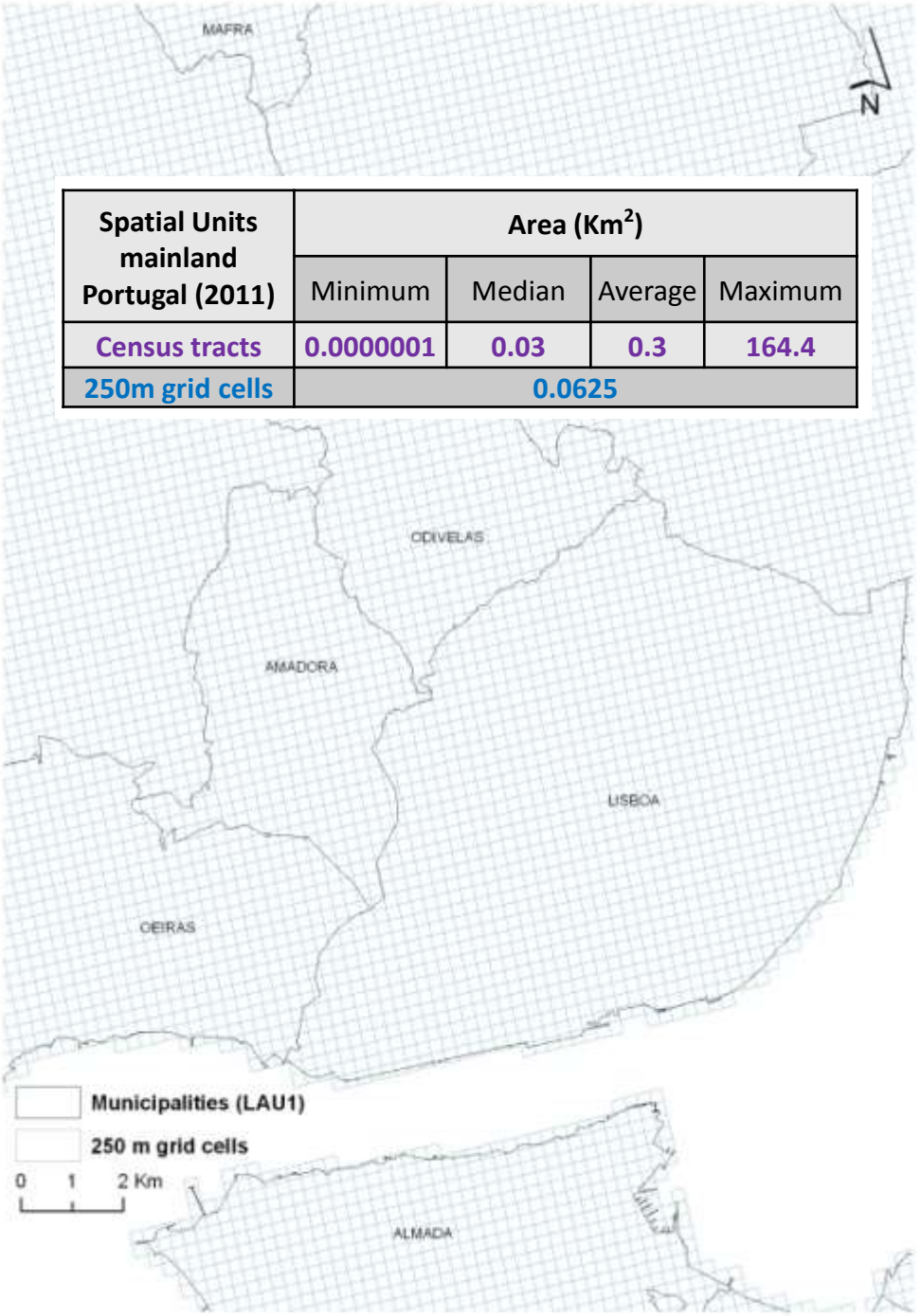
Methods

The approach was tested for mainland Portugal using two types of spatial units:

- Census tracts (255 844 units);
- 250 m grid cells (1 431 305 units).

Some steps differ slightly depending on the spatial units in use.

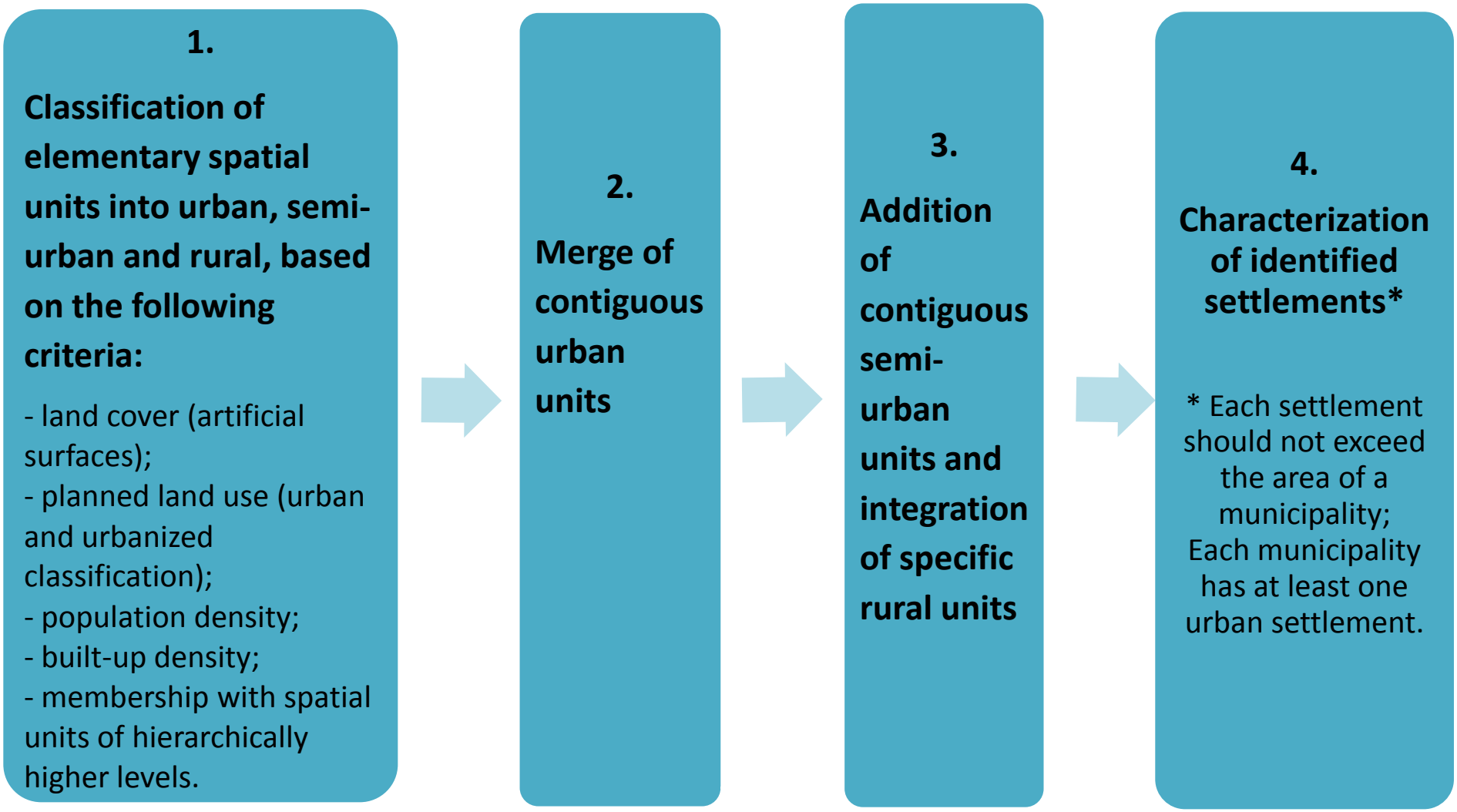




Spatial Units mainland Portugal (2011)	Area (Km^2)			
	Minimum	Median	Average	Maximum
Census tracts	0.0000001	0.03	0.3	164.4
250m grid cells	0.0625			

Methods

Procedural steps for settlements identification:



1. Classification of elementary spatial units

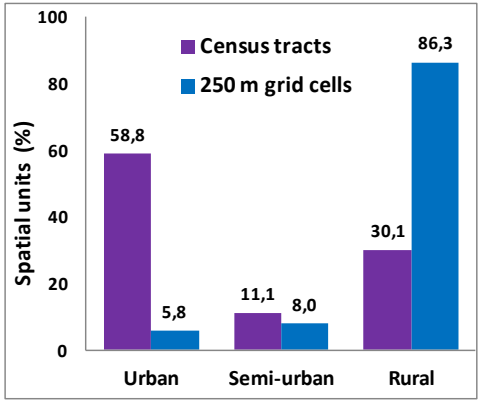
Urban units have:

- more than 50% of its surface already urbanized (Master Plan classification) **or**
- a population density **or** a buildings density above the median[1] /average[2] **and**
- comply with at least one of the following criteria:
  - ❖ more than 50% of its surface is classified as urban by Master Plan;
  - ❖ more than 50% of its surface is classified as artificial surface by COS2007;
  - ❖ belong to a locality with ≥5000 inhabitants **and** to a census enumeration area with > 500 inhabitants/km2 (membership criteria with spatial units of hierarchically higher levels);

Rural units have:

- a population density **and** a buildings density below or equal to the median[1] /average[2] **and**
- equal or less than 50% of its surface is classified:
  - ❖ as urban by Master Plan **and**
  - ❖ as artificial surface by COS2007;

Remaining spatial units are classified as Semi-urban.



1 - census tracts

2 - 250 m grid cells

Descriptive statistics of census variables by census tracts and by 250 m grid cells mainland Portugal (2011)

	Minimum	P25	Median P50	Average	P75	Maximum	Standard Deviation
Inhabitants	0	7	20	39.3	44	1742	65.0
	0	0	0	7.0	0	2835	50.5
Inhabitants /km^2	0.0	155.6	651.9	3036.8	2810.0	288617.7	6321.2
	0.0	0.0	0.0	112.3	0.0	45360.0	807.8
Buildings	0	5	10	13.1	17	773	12.8
	0	0	0	2.3	0	844	10.6
Buildings /km^2	0.0	104.5	360.2	969.4	1149.0	47053.2	1614.9
	0.0	0.0	0.0	37.5	0.0	13504.0	169.6

3. Addition of contiguous semi-urban units and integration of specific rural units

Census tracts

a. Addition of contiguous semi-urban units, within each municipality (iterative addition process);

b. Generation of 100 meters buffers around the areas resulting from a.;

c. Addition, within each municipality, of rural units that simultaneously meet the following criteria:

   - are contiguous to areas resulting from a. and have a smaller surface than one of its adjacent areas;
   - have at least 50% of its surface contained in buffers set at b.

d. Addition, within each municipality, of contiguous semi-urban units (iterative addition process).

250 m grid cells

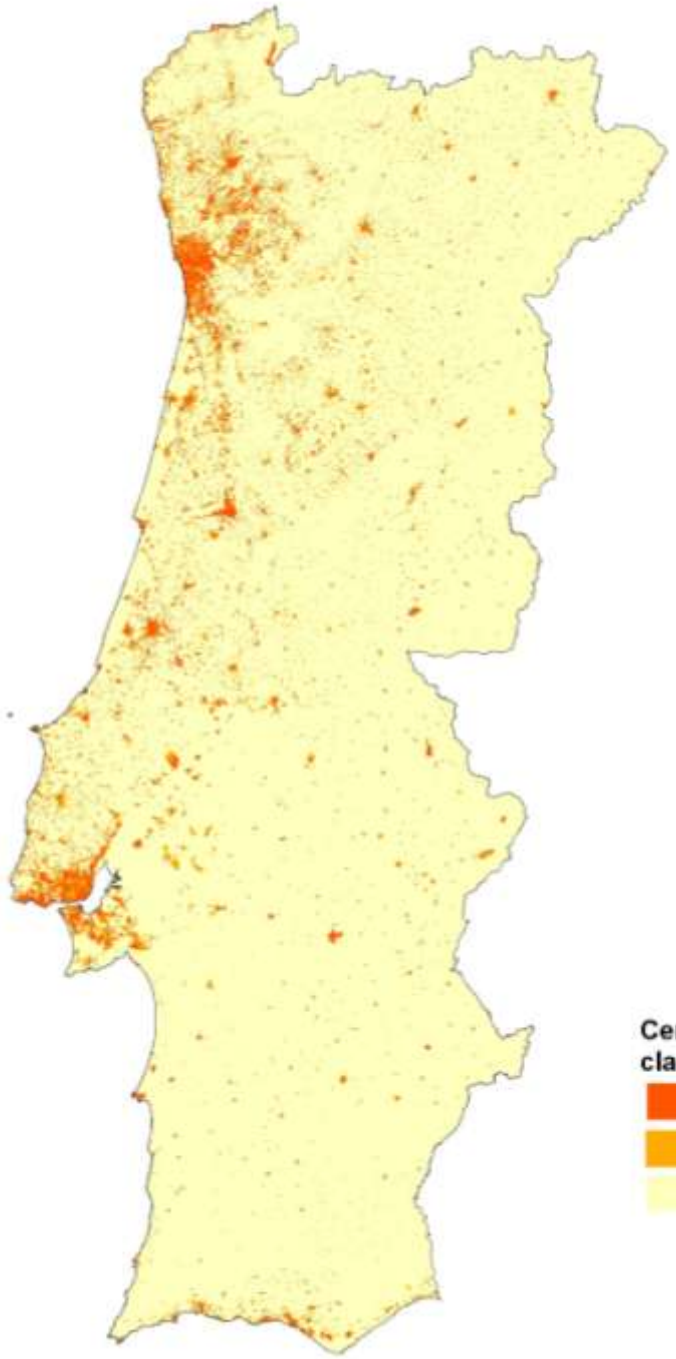
a. Addition of contiguous semi-urban units (only 1st order neighbors);

b. Addition of semi-urban and rural units to ensure the connection of polygons resulting from a. that are less than 353.55 m apart and the suppression of enclaves (polygon holes) with less than 62500 m^2;

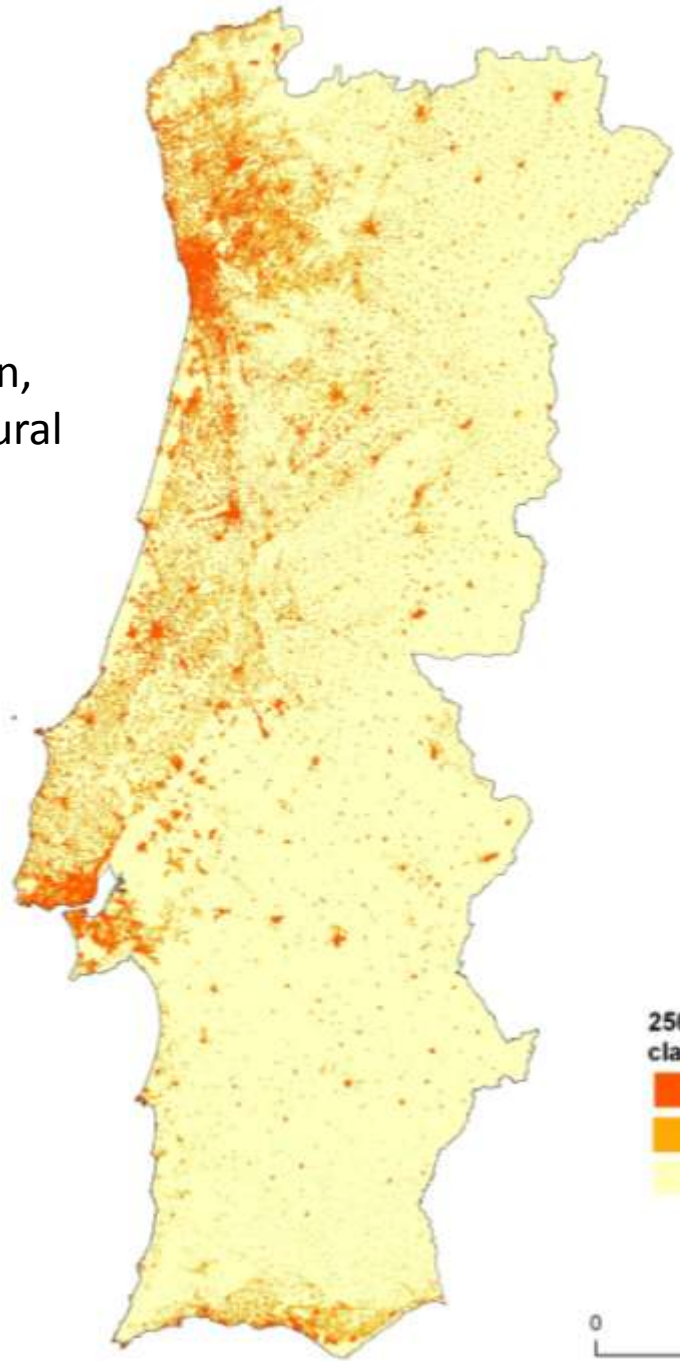
c. Subdivision of polygons resulting from b. by municipalities.

Results

Classification of spatial units according to urban, semi-urban and rural categories



Census tracts classification (2011)
Urban
Semi-urban
Rural



250 m grid cells classification (2011)
Urban
Semi-urban
Rural

N

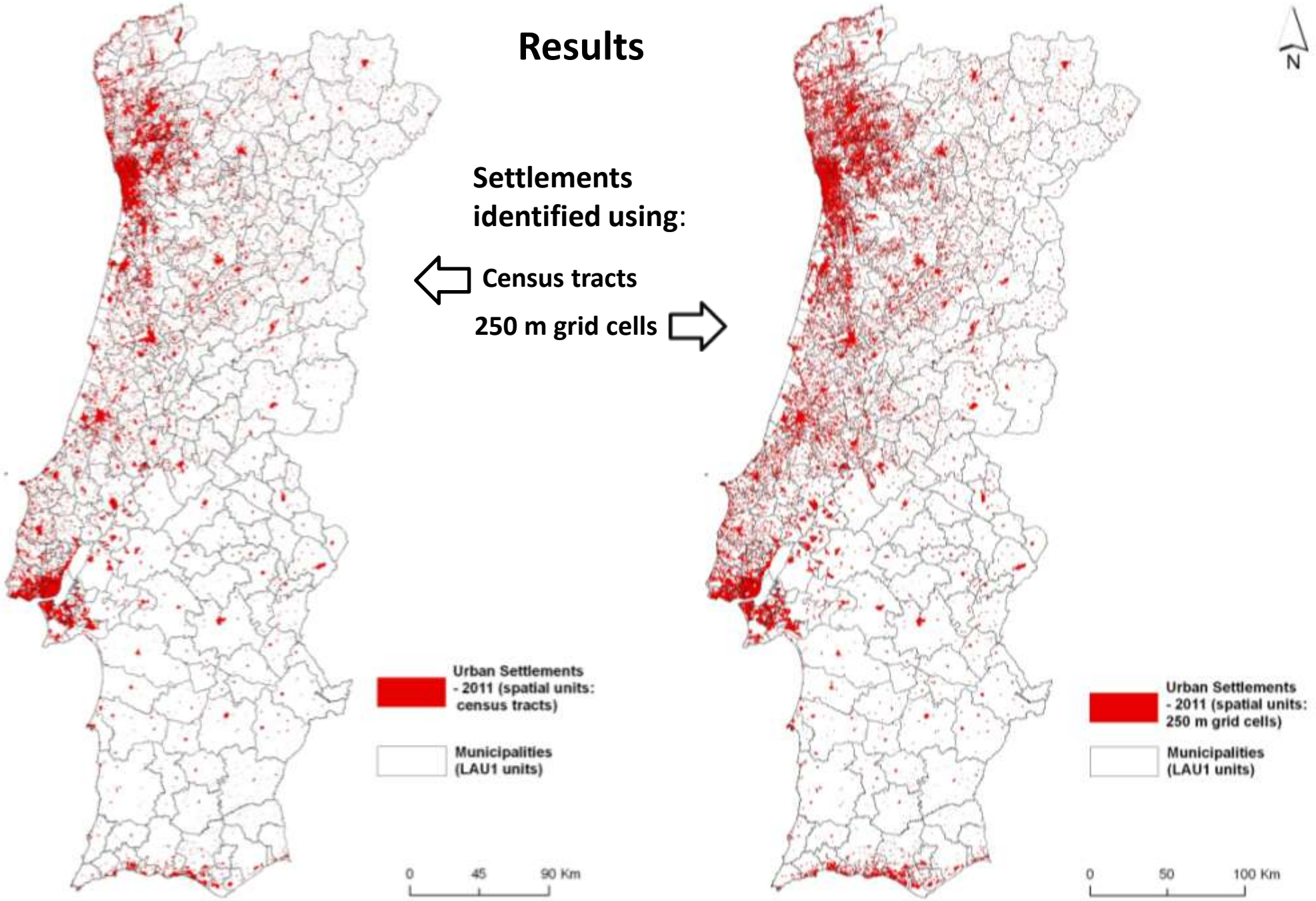
0 50 100 Km

Results

Settlements identified using:

Census tracts

250 m grid cells

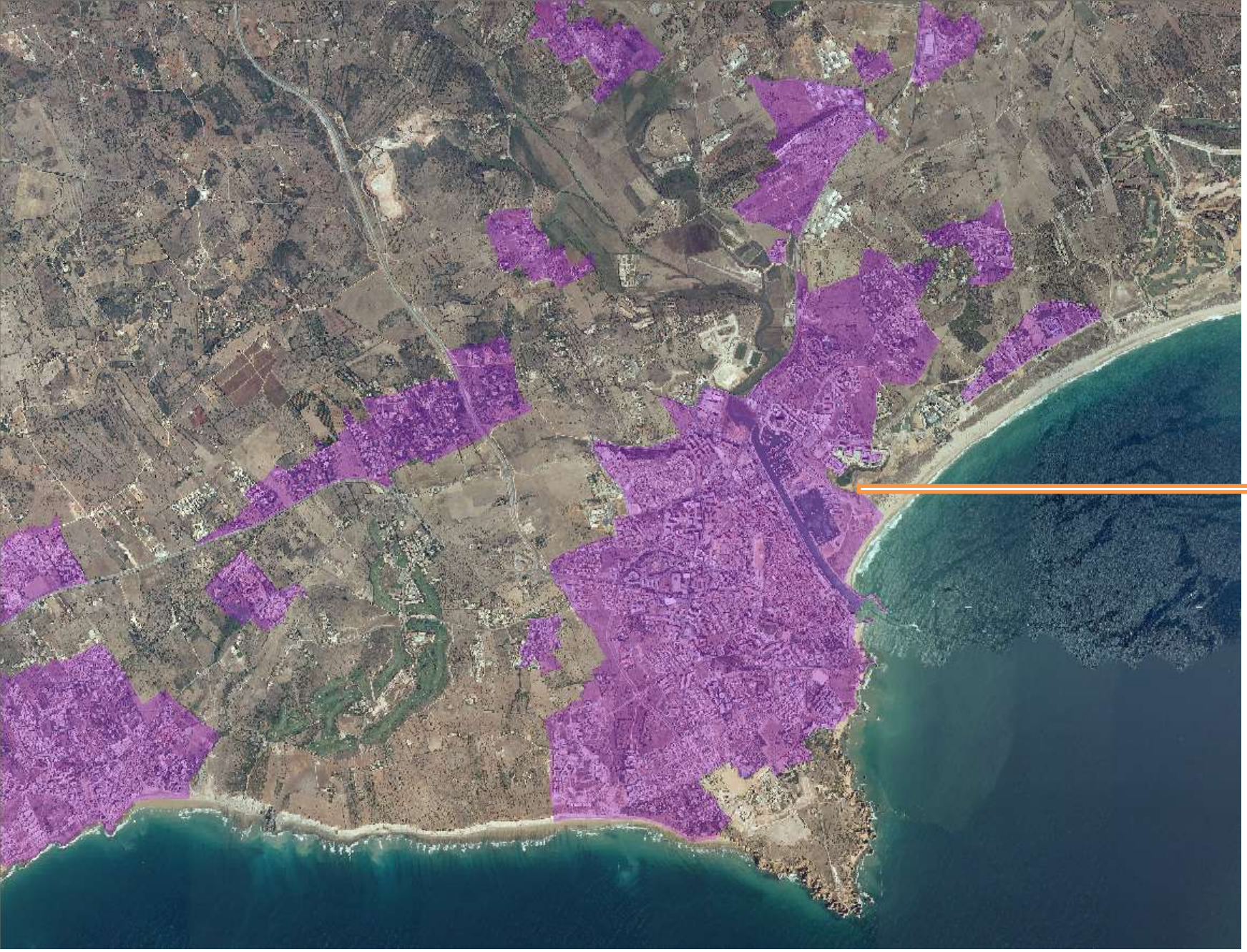


Spatial Units	Settlements Area (Km^2)		
	Minimum	Average	Maximum
Census tracts	0.00007	0.62	128.88
250 m grid cells	0.00000007	1.36	141.73

Lagos

Urban settlement that includes the municipal headquarter

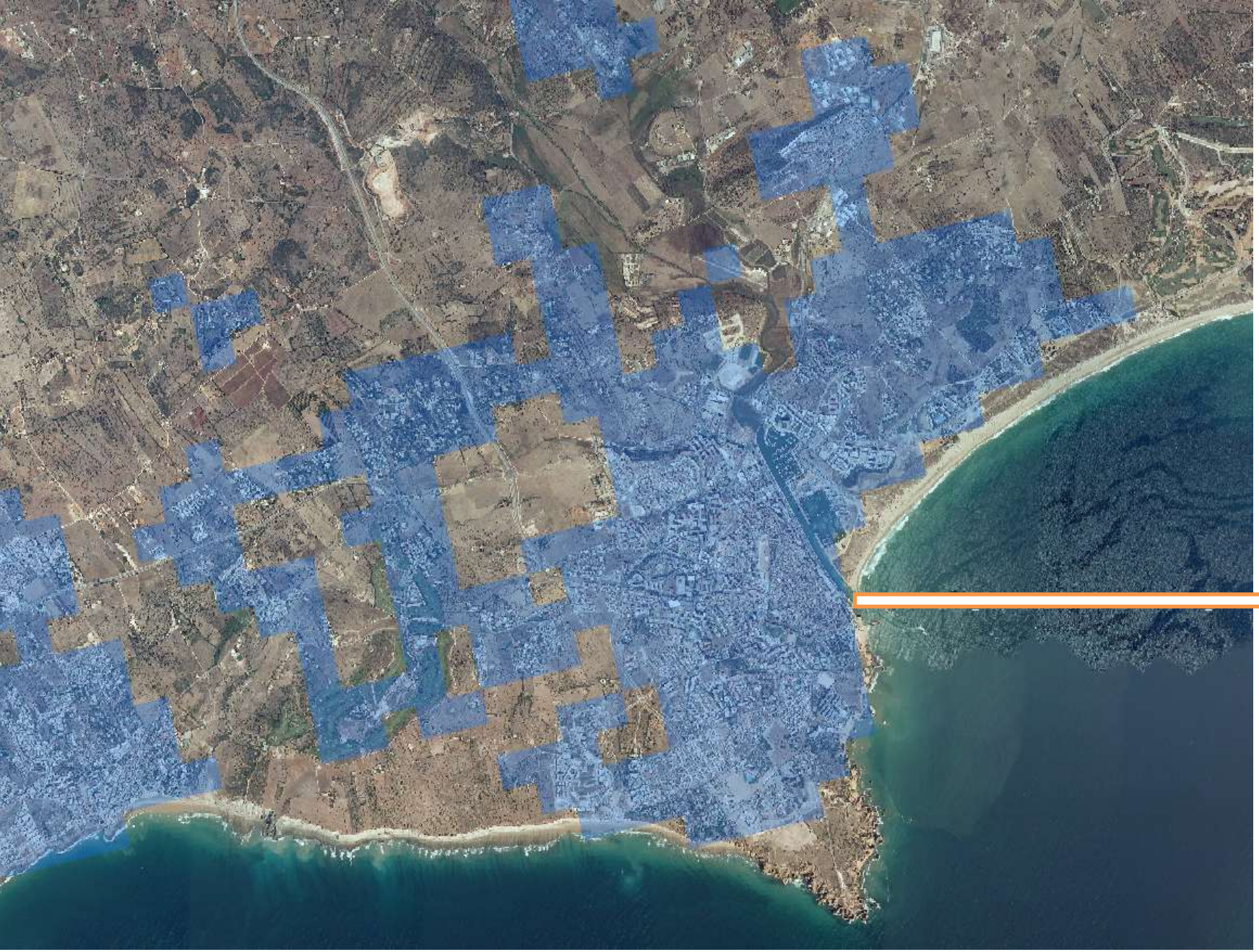
Lagos



18 557 inhabitants (59.8% of municipal inhabitants)

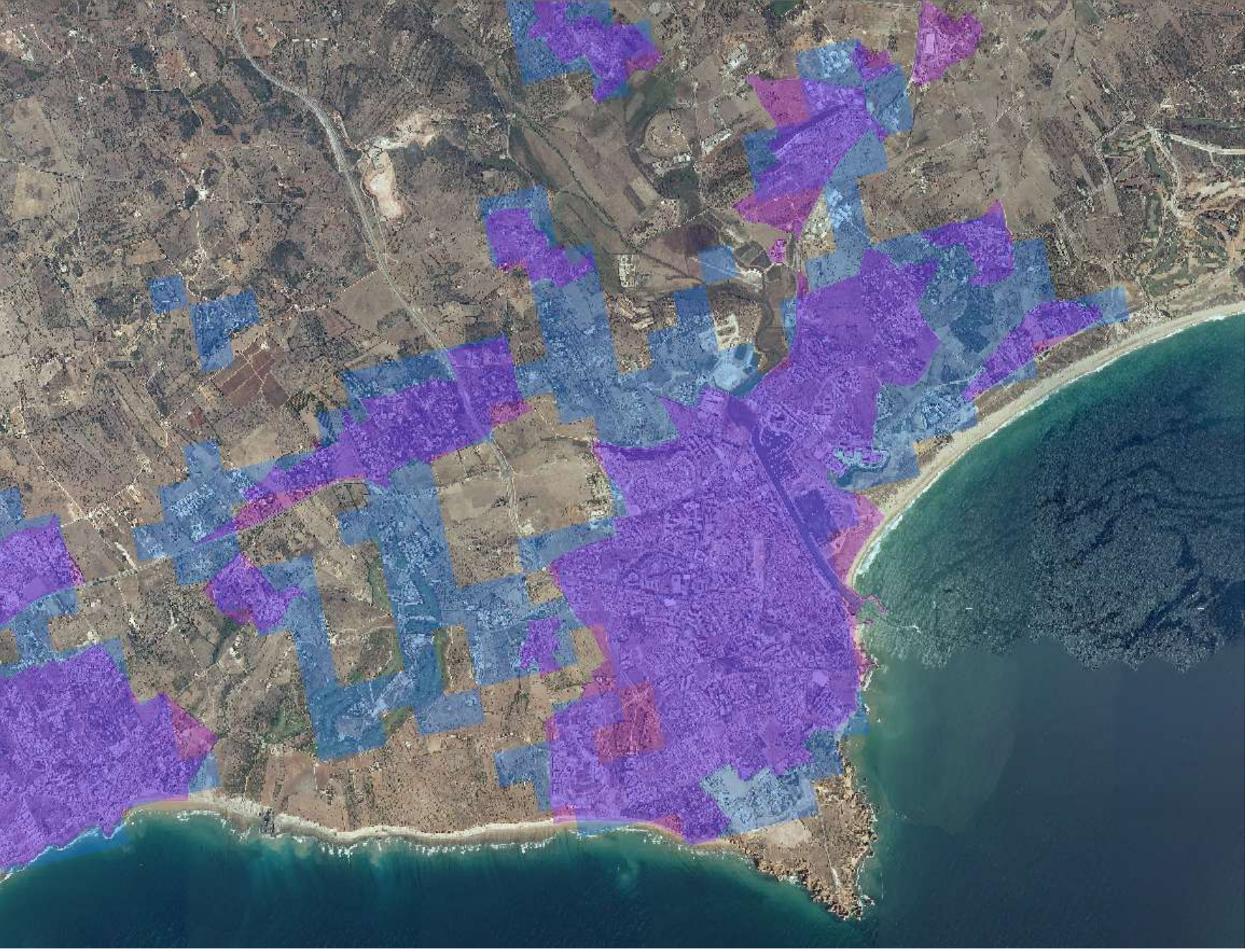
Urban settlements identified using census tracts

Lagos



21 424 inhabitants (69% of municipal inhabitants)

Urban settlements identified using 250 m grid cells



Lagos

Overlay of urban settlements identified using different spatial supports

Results

Our results show that urban settlements' limits are not confined to administrative boundaries.

The number of urban settlements and their spatial extent vary substantially with the spatial units in use:

Census tracts → identification of **10228 settlements**, representing **86.9% of mainland population** (2011) and **7.1% of its surface**;

250 m grid cells → identification of **6971 settlements**, representing **93.5% of mainland population** (2011) and **10.7% of its surface**.

- The use of 250 m grid cells promotes settlements' grouping, reducing the number of identified settlements. Therefore, less settlements were identified when using 250 m grid cells.
- Due to the larger average area of the settlements identified using 250 m grid cells (1.36 vs 0.62 Km^2) the corresponding estimate of urban population is also higher;
- All the settlements identified using census tracts were also identified with the 250 m grid cells.
- Both spatial supports generate similar rankings of urban settlements by population size.

Results

- Although most of mainland population lives in settlements with 5000 or more inhabitants, the majority of identified settlements (97.3 vs 98.3%) have less than 5000 inhabitants.
- In almost 50% of Portuguese municipalities, the largest urban settlement has less than 5000 inhabitants. Therefore, to ensure the characterization of at least one urban area by municipality, we need an approach and elementary spatial units that guarantees the identification of those small sized settlements.

Urban settlements by population size - 2011

Inhabitants	Census tracts				250 m grid cells			
	Urban settlements		Mainland population covered		Urban settlements		Mainland population covered	
	Nº	%	Nº	%	Nº	%	Nº	%
< 5 000	10 055	98.3	2 226 490	22.2	6 783	97.3	1 879 677	18.7
5 000 - 9 999	68	0.7	473 968	4.7	66	0.9	468 314	4.7
10 000 - 49 999	76	0.7	1 694 741	16.9	83	1.2	1 828 497	18.2
50 000 - 99 999	9	0.1	624 939	6.2	18	0.3	1 156 454	11.5
100 000 - 249 999	17	0.2	2 556 908	25.4	18	0.3	2 845 462	28.3
≥ 250 000	3	0.03	1 157 369	11.5	3	0.04	1 218 146	12.1
Total	**10 228**	**100**	**8 734 415**	**86.9**	**6 971**	**100.0**	**9 396 550**	**93.5**

Discussion and Conclusions

The proposed approach is not independent of the spatial units' detail. The procedural steps applied to census tracts are not fully replicable to 250 m grid cells.

The detail provided by 250 m grid cells does not seem to be appropriate to delineate the urban settlements of interest, because:

- It overestimates the spatial extent of the identified settlements and corresponding population;
- It does not estimate accurately the number of inhabitants of settlements that were divided by municipalities limits;
- It's too coarse.

The detail provided by census tracts seems to be more appropriate, although:

- The larger size of rural census tracts does not allow a faithful reproduction of the settlements' boundaries;
- An underestimation of the spatial extent of the identified settlements and corresponding population seems to exist.

Discussion and Conclusions

The added value of the proposed methodology is based on the diversity and complementarity of the data sources that were integrated.

However one recognizes that the integration of datasets with different scales and varying spatial and temporal extents produces errors, which quantification is beyond the scope of this study.

Future Developments

- Compare the results of the present approach with an alternative one, based on the Urban Morphological Zones[1] (UMZ proposed by the EEA).
- Perform a functional analysis focused on selected urban settlements.

[1] **Simon A, Fons J, Milego R** (2010). Urban Morphological Zones version F2v0 – Definition and procedural steps. European Topic Centre Land Use and Spatial Information, European Environment Agency.

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Thank you!

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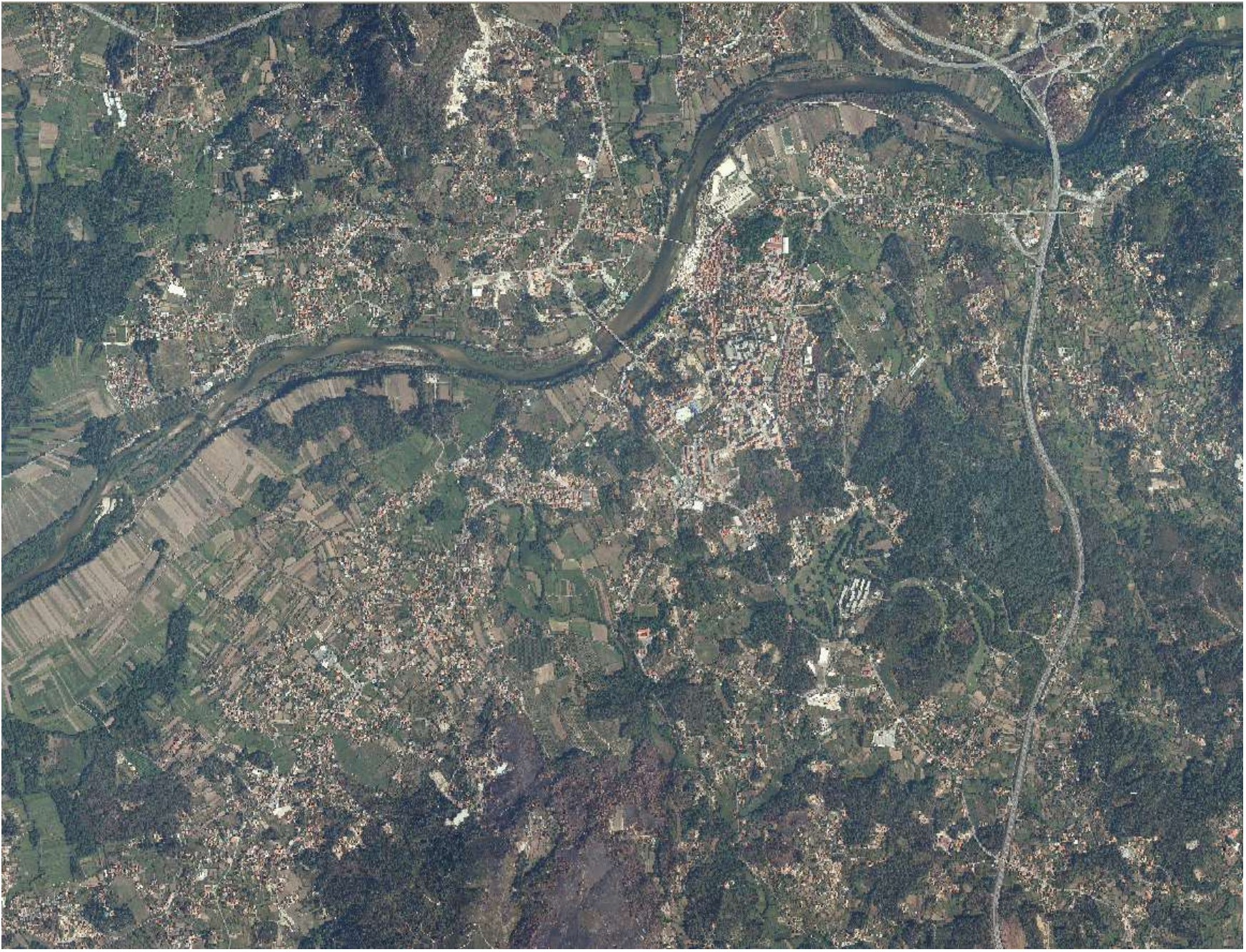
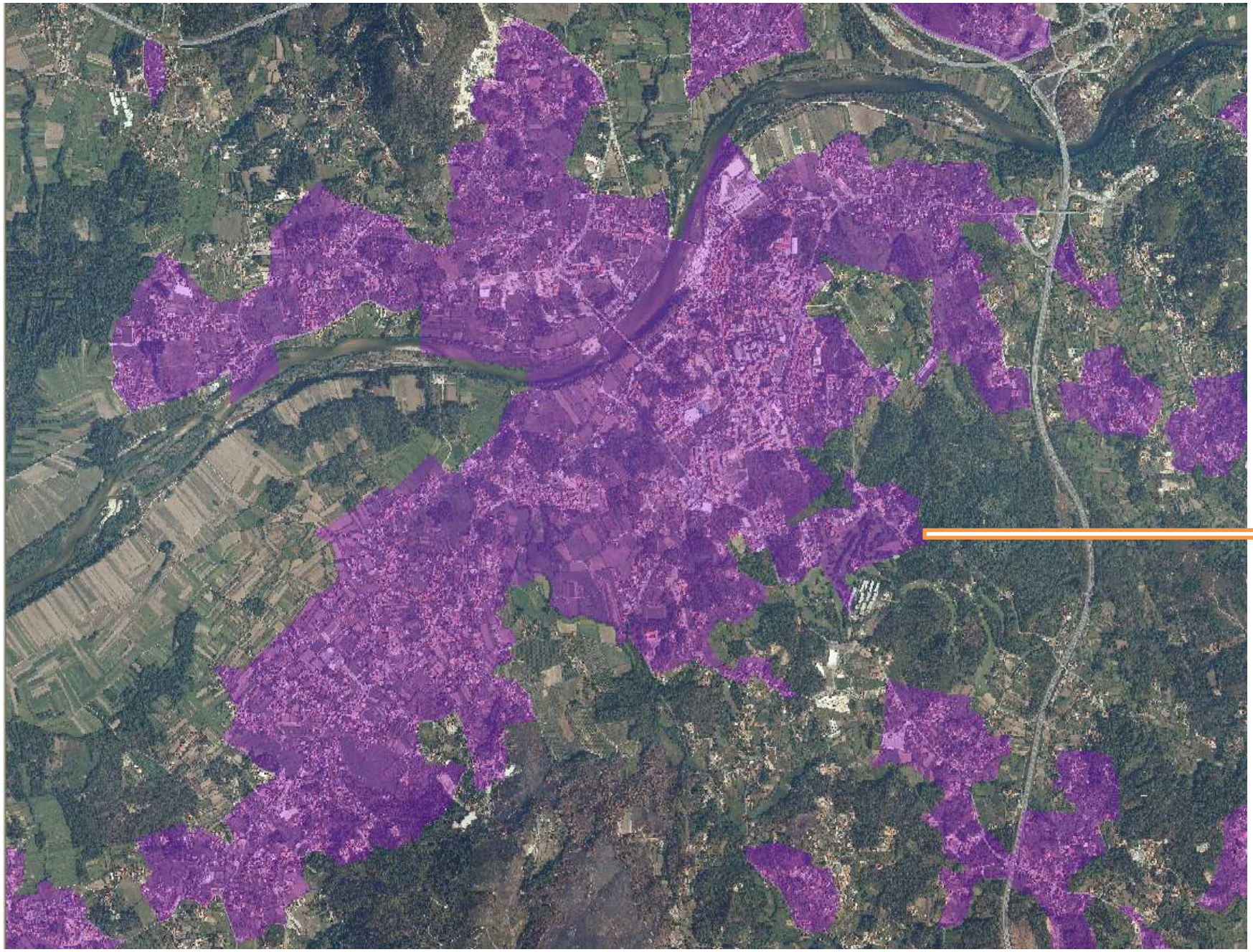
Ponte de Lima



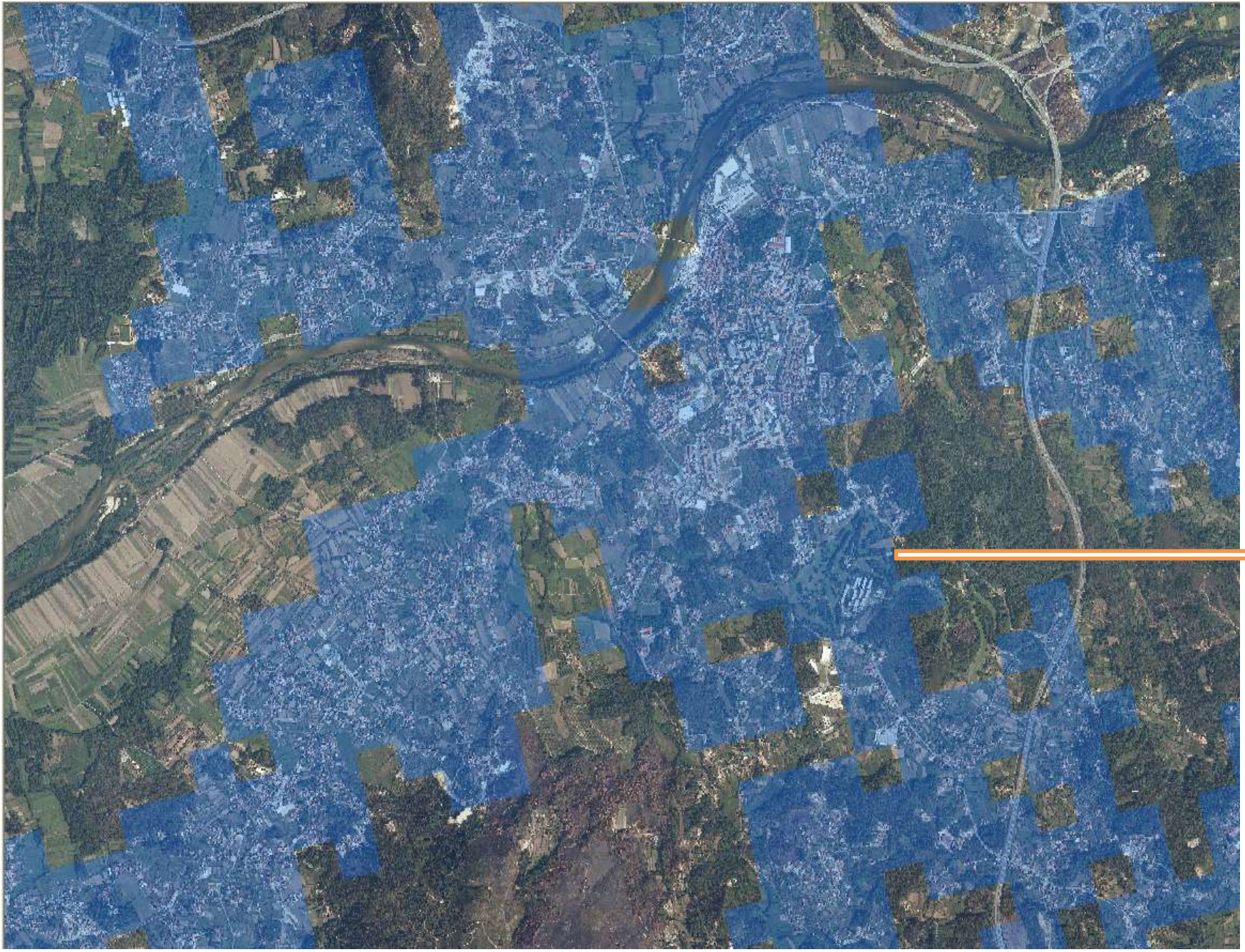
Urban settlement that includes the municipal headquarter

Ponte de Lima



10 228 inhabitants (23.5% of municipal inhabitants)

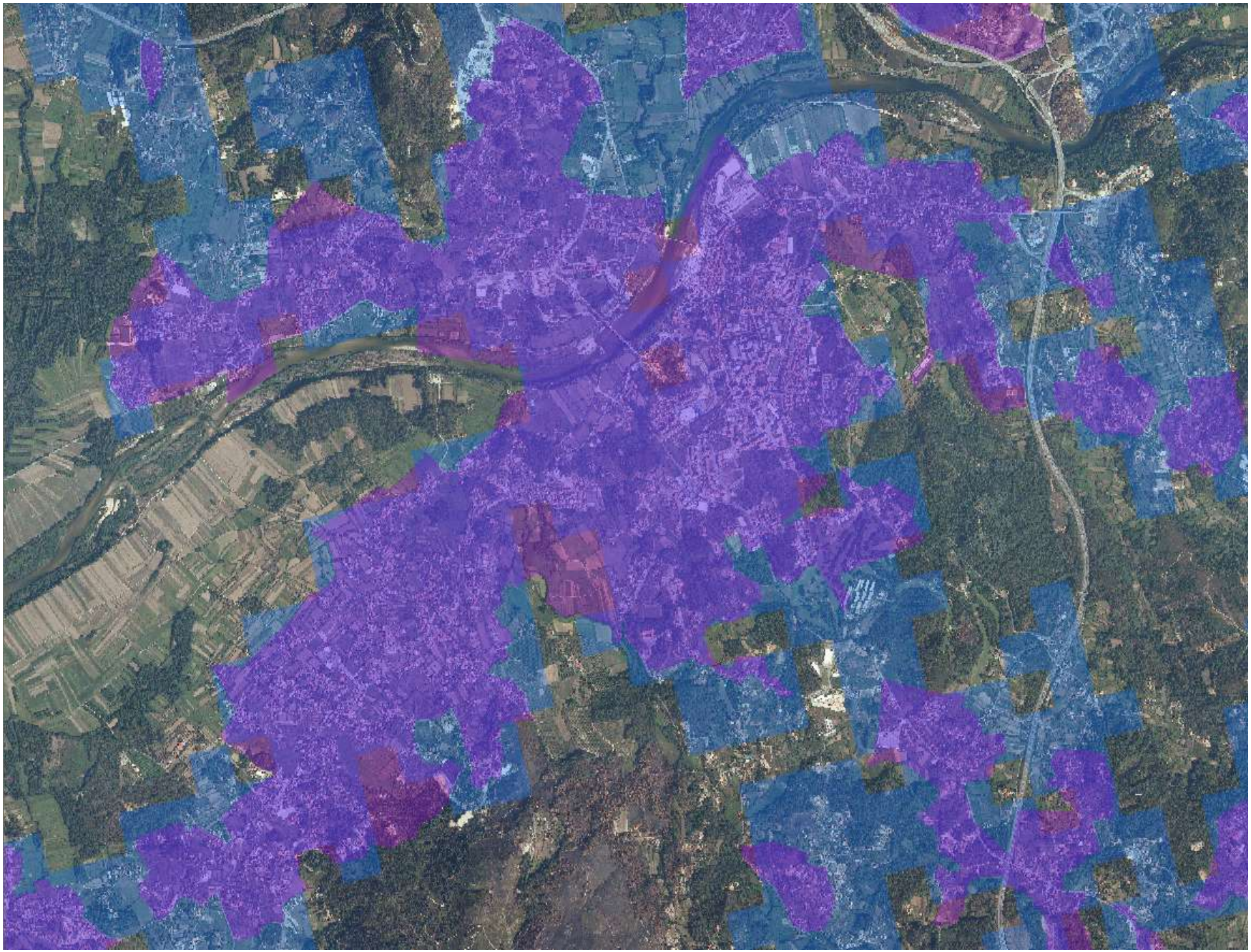
Urban settlements identified using census tracts



Ponte de Lima

23 184 inhabitants (53.3% of municipal inhabitants)

Urban settlements identified using 250 m grid cells

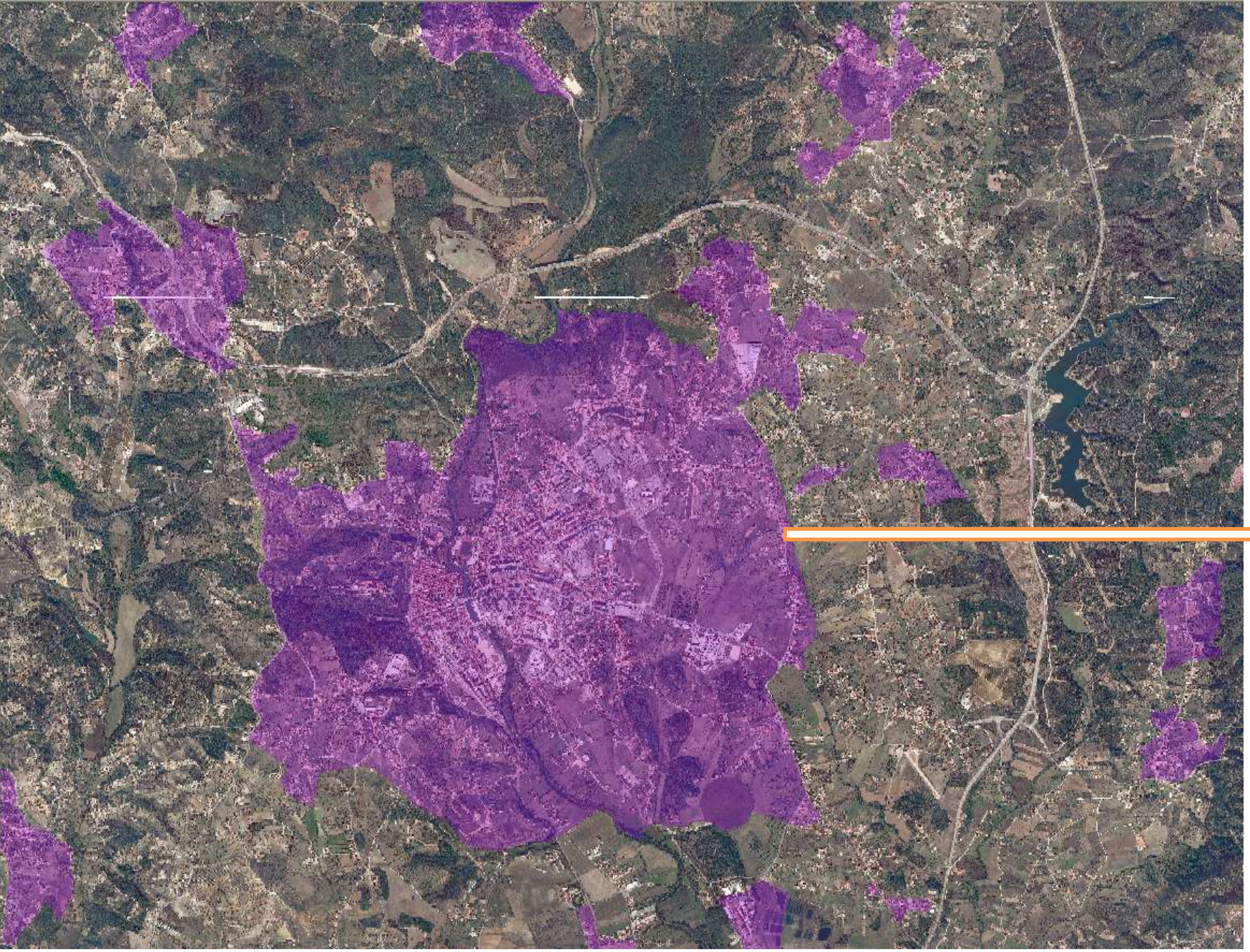


Overlay of urban settlements identified using different spatial supports

Tomar

Urban settlement that includes the municipal headquarter

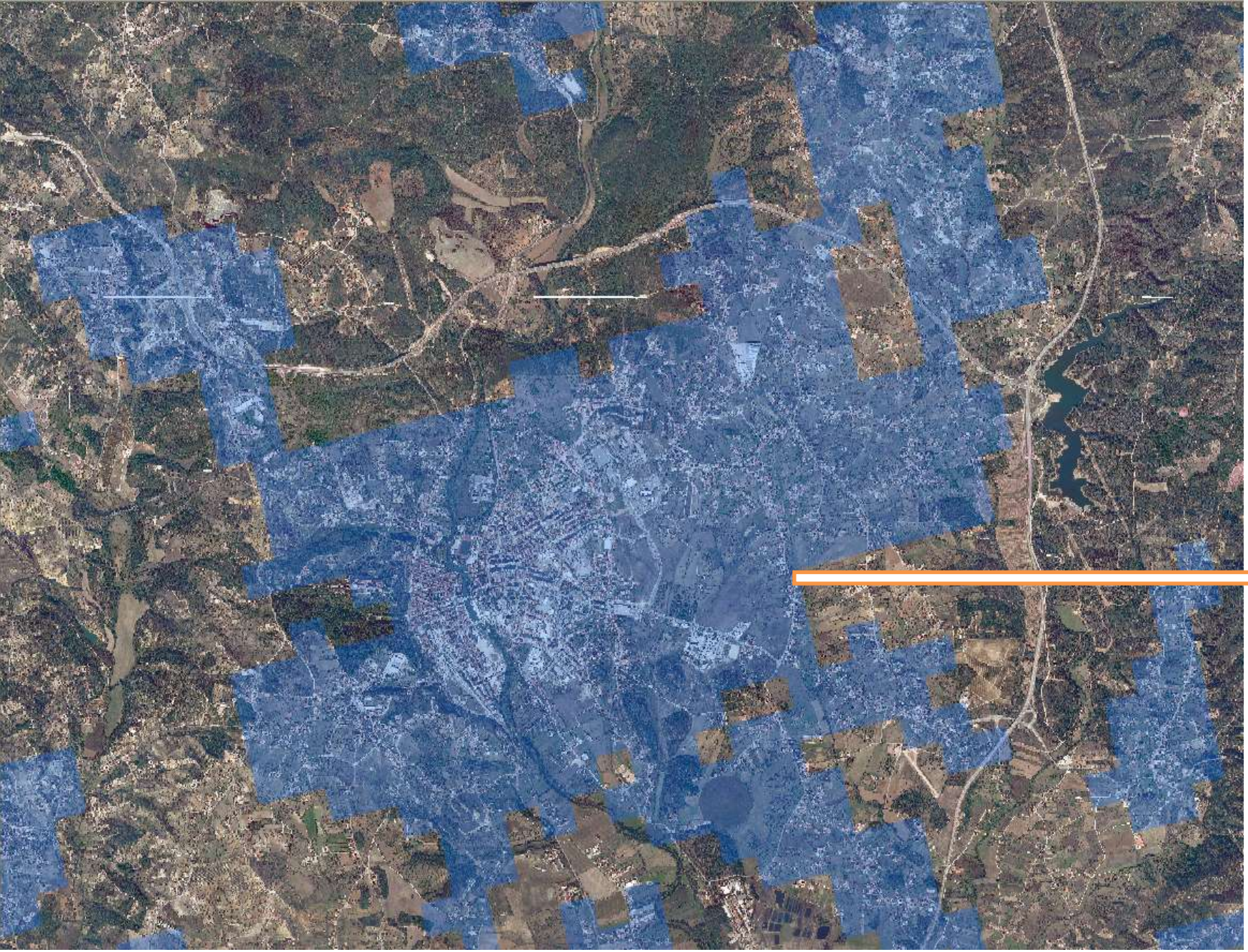
Tomar



15 413 inhabitants (37.9% of municipal inhabitants

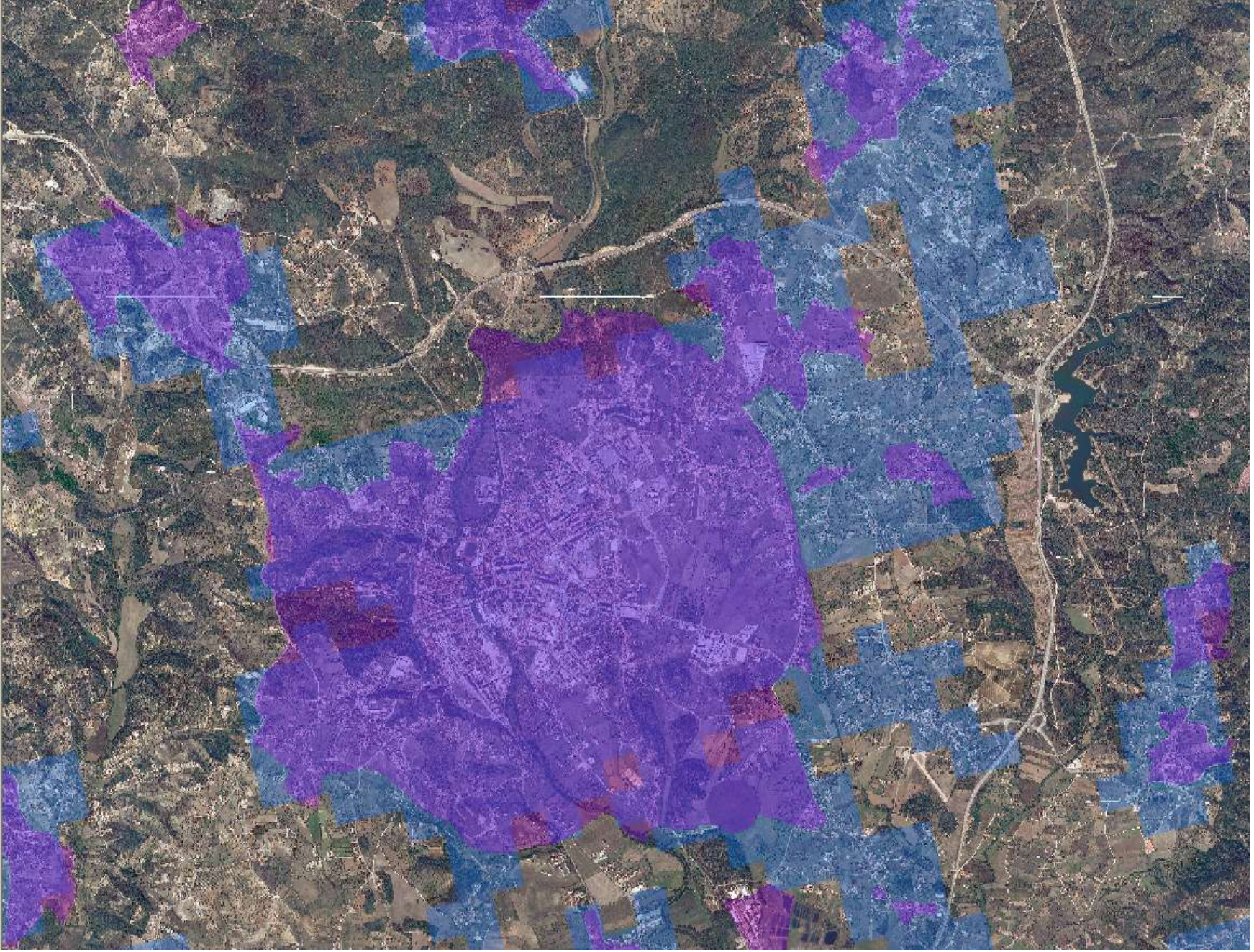
Urban settlements identified using census tracts

Tomar



22 936 inhabitants (56.4% of municipal inhabitants

Urban settlements identified using 250 m grid cells



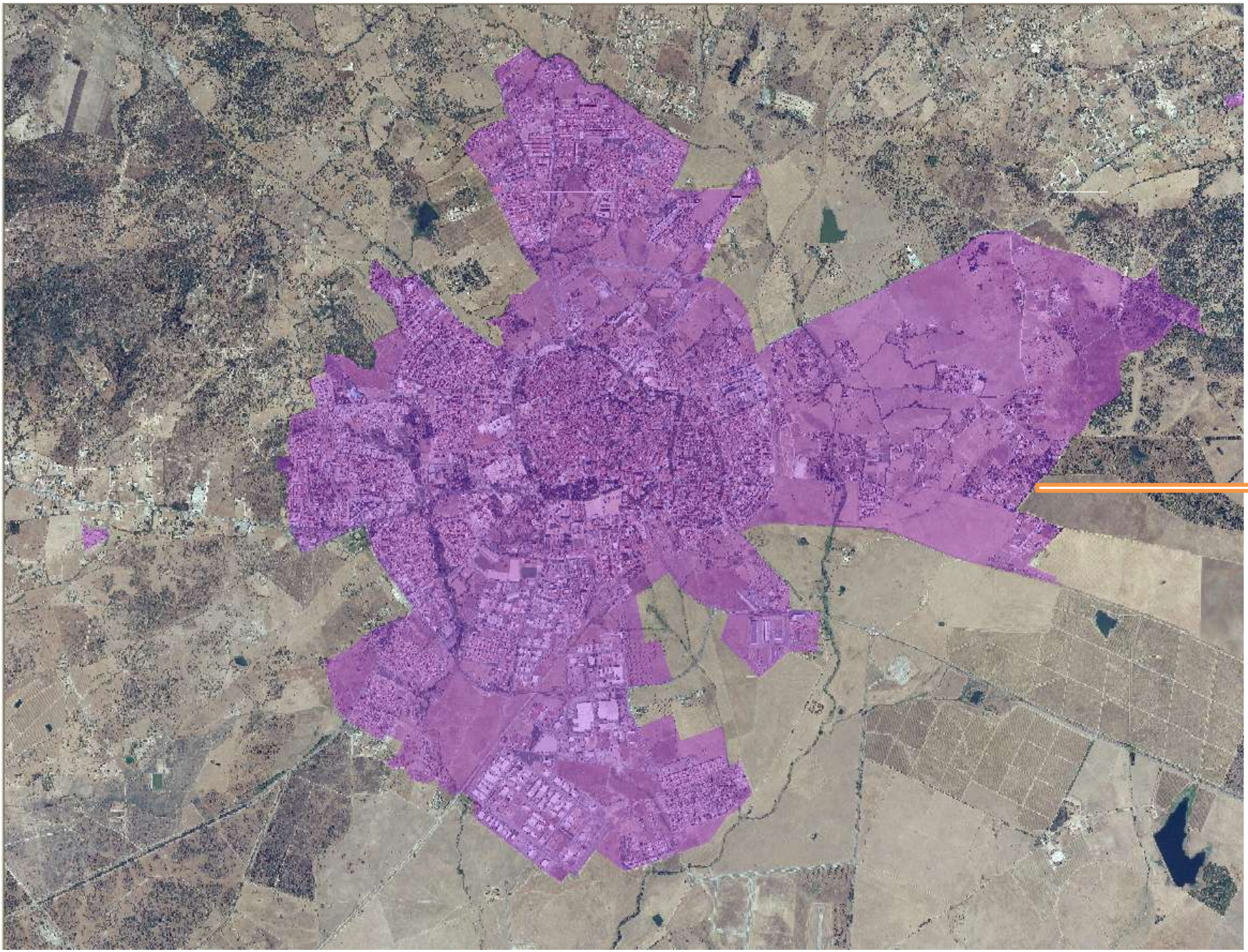
Tomar

Overlay of urban settlements identified using different spatial supports

Évora

Urban settlement that includes the municipal headquarter

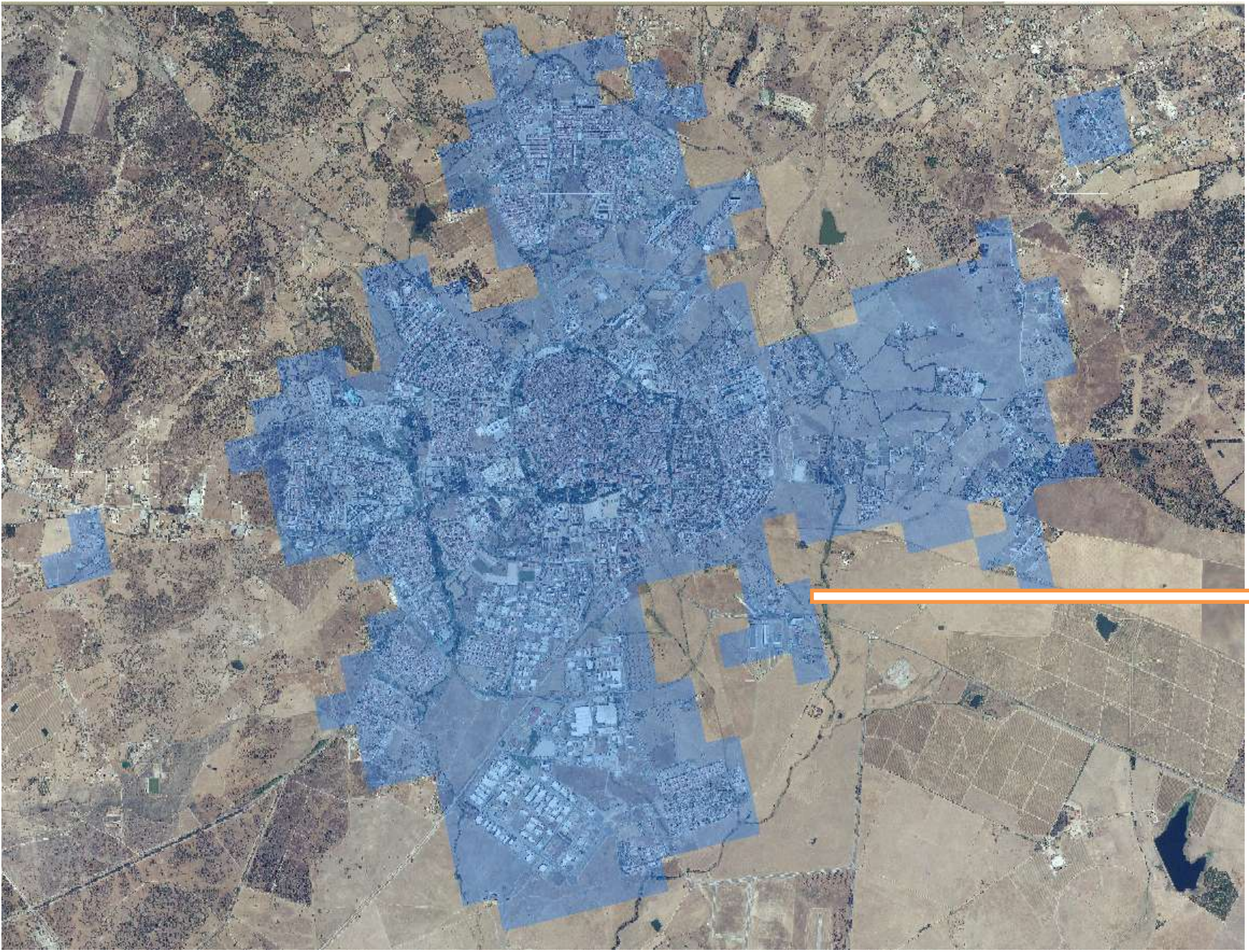
Évora



43 090 inhabitants (76.1% of municipal inhabitants)

Urban settlements identified using census tracts

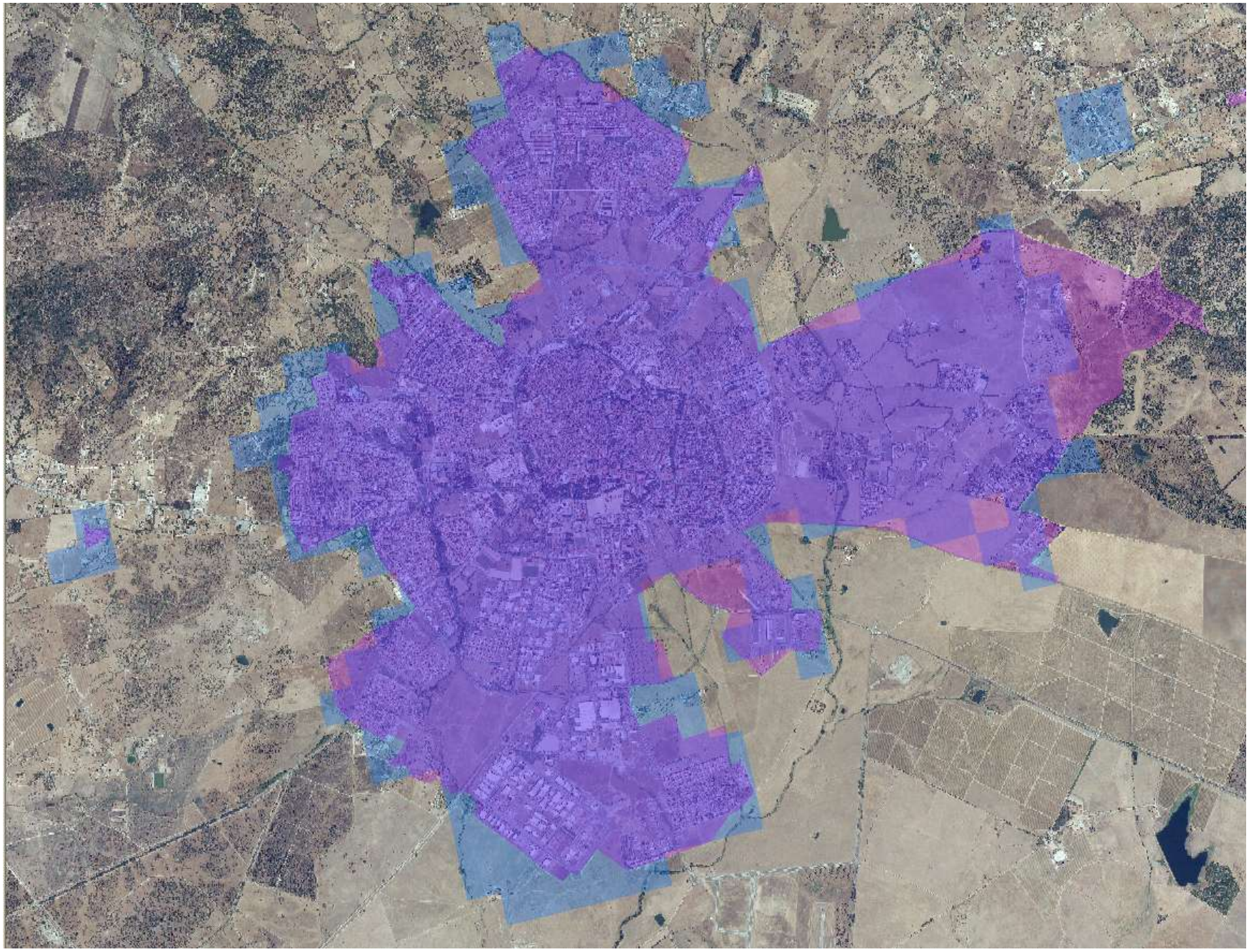
Évora



43 297 inhabitants (76.5% of municipal inhabitants)

Urban settlements identified using 250 m grid cells

Évora



Overlay of urban settlements identified using different spatial supports