# Comparison of indicator 11.3.1 estimates provided by distinct assumptions on the urban population distribution

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## Goals

- Presentation of a methodological approach for the assessment of the indicator 11.3.1: "Ratio of Land Consumption Rate to Population Growth Rate" proposed by the United Nations (UN).
- Comparison of preliminary estimates of the indicator provided by different assumptions concerning the urban population distribution, based on the results obtained for Mainland Portugal, at the municipality level.

## Introduction

- In 2015, the UN agenda established a set of 17 Sustainable Development Goals (SDG) and 169 targets, to be reached by all countries by 2030.
- In 2016, the Statistical Commission of UN proposed a set of 241 indicators for monitoring the SDG.
- One of the indicators proposed is the "ratio of Land Consumption Rate to Population Growth Rate", which is also known as indicator 11.3.1.
- This indicator is associated with the SDG 11 ("Make cities inclusive, safe, resilient and sustainable") and more specifically with the target 11.3 that aims a more sustainable growth of cities, among other aspects (UN-Habitat, 2018).

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## Introduction

• The indicator 11.3.1 aims at monitoring and measuring urban development by comparing the urban expansion rate with the population growth rate on similar temporal and spatial scales.

• Due to specific limitations related to the formula initially proposed by the UN for the computation of the indicator 11.3.1, an alternative formulation derived from Land Use Efficiency (LUE) was explored.

• The LUE formula used in this study has been proposed by Corbane et al. (2017) and measures the change rate of the built-up area per capita in a given period.

• The LUE may be faced as a proxy of the indicator 11.3.1, when it is assumed that the surface occupied by built-up also includes the open urban space, being, therefore, equivalent to the surface occupied by urban areas.

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## Methods

• In this study, the urban surface was extracted from the Portuguese Land Cover Land Use maps for 2010 and 2015 (COS 2010; COS 2015). The land cover classes chosen to represent the urban areas were the Artificial areas (1) excluding Construction sites (133).

• The measurement of the surface of each municipality occupied by urban areas at different years was carried out using the same administrative limits, which correspond to the municipalities boundaries in 2013.

• To determine the inhabitants in urban areas, we used estimates of the resident population by municipality produced by Statistics Portugal, for 2010 and 2015.

• We tested two assumptions concerning the distribution of the urban population in Mainland:

a) A simplified (S) assumption, which admits that the urban inhabitants may be represented by the residents in administrative units, to which the urban areas pertain (i.e. the entire population lives in urban areas).

b) A more pragmatic (P) assumption, which admits that although most of the population is concentrated in urban areas, there is a small share living outside urban areas.

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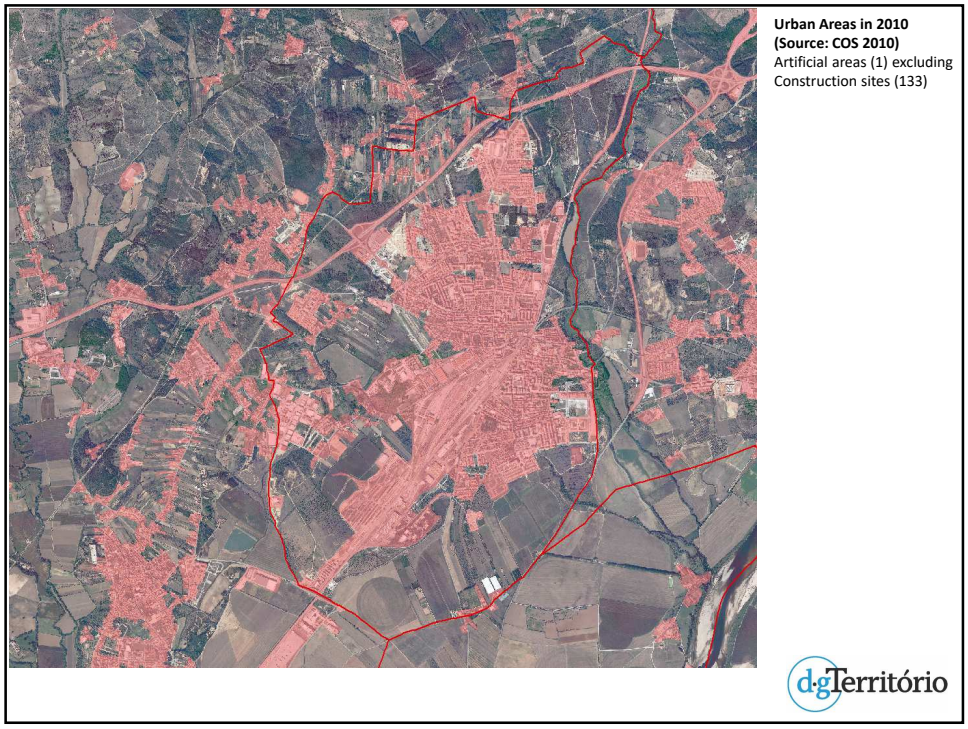
## Methods

• The assessment of the urban population based on assumption P was performed in two steps:

1) The distribution of the population (linked to administrative units) per land cover classes that represent residential areas, by a dasymetric mapping technique which used COS as ancillary information. The following classes were considered as residential areas: Continuous urban fabric (111); Discontinuous urban fabric (112); Sports, leisure and cultural facilities, and historic zones (142); and Complex cultivation patterns (242). The inclusion of the class 242 among the residential areas of the territory is due to the fact that these agricultural areas contain dispersed dwellings.

2) The overlay of the urban areas with the population distribution produced by the former allocation, to determine the inhabitants of urban areas, within each municipality.


Urban Areas in 2010
(Source: COS 2010)
Artificial areas (1) excluding
Construction sites (133)
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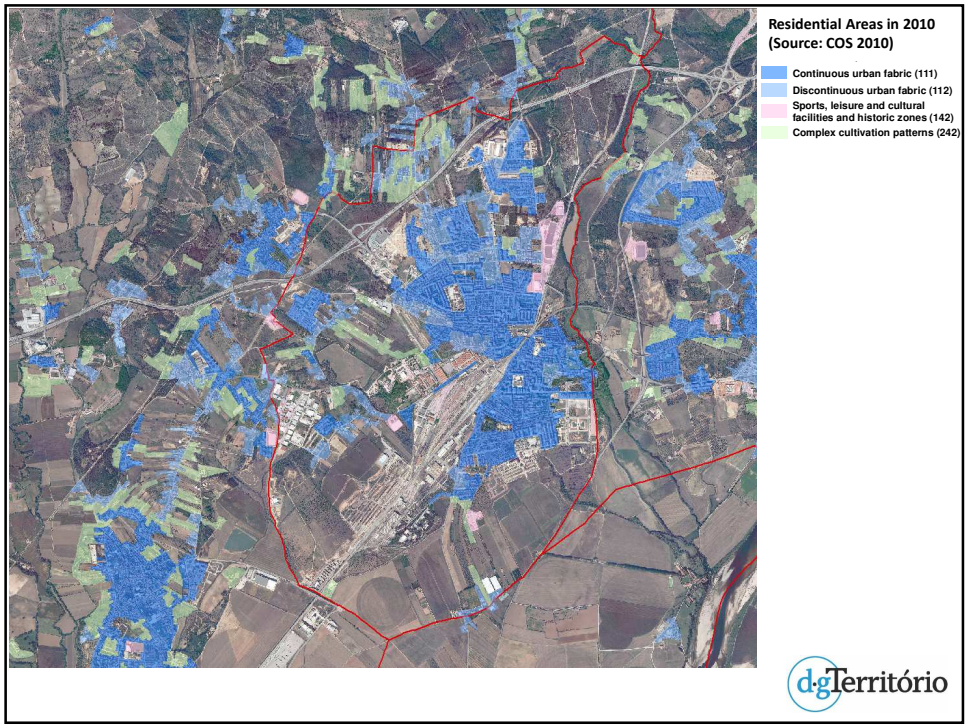
Residential Areas in 2010
(Source: COS 2010)
Continuous urban fabric (111)
Discontinuous urban fabric (112)
Sports, leisure and cultural facilities and historic zones (142)
Complex cultivation patterns (242)
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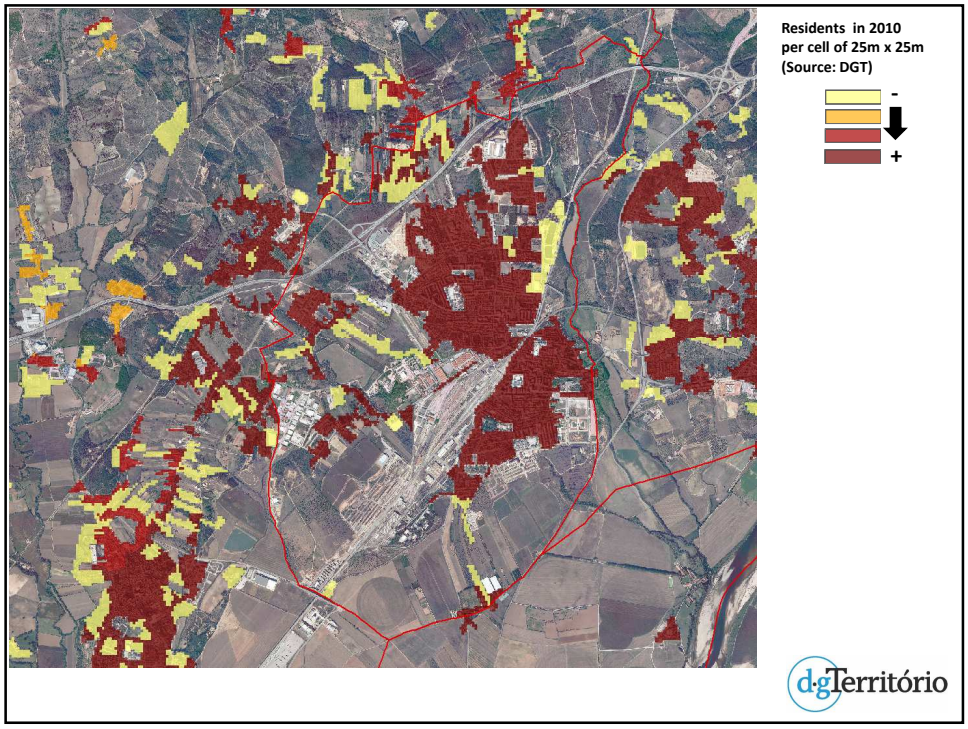
Residents in 2010
per cell of 25m x 25m
(Source: DGT)
-
+
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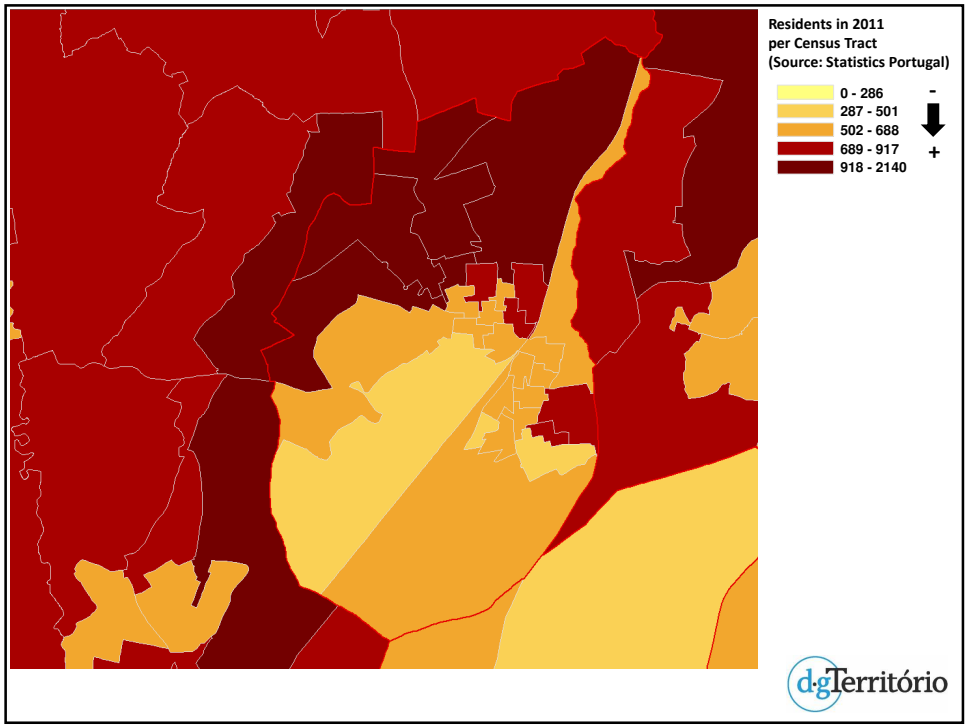
Residents in 2011
per Census Tract
(Source: Statistics Portugal)
0 - 286
287 - 501
502 - 688
689 - 917
918 - 2140
-
+
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## Results

The results presented herein correspond to estimates of the LUE indicator for the period 2010-2015 which are designated by LUE-S and LUE-P, according to the assumption on urban population distribution (S or P) adopted in its calculation.

• In the period 2010-2015:

- The surface occupied by urban areas increased in almost all the municipalities (97%) and in the Mainland. The average urban soil consumption rate per municipality was about 3.5%.

- The Mainland and the majority of the municipalities (90%) lost inhabitants. The urban population (assessed by P) also declined in 90% of the municipalities.

- The LUE-S and LUE-P estimates were negative both in the Mainland and in most municipalities (94.6%). These negative values of the LUE are explained by the expansion of urban areas accompanied by the decrease of the urban residents.

- Most municipalities with positive estimates of LUE belong to the fringe of Lisbon Metropolitan Area, where urban soil consumption was slower than urban population growth.

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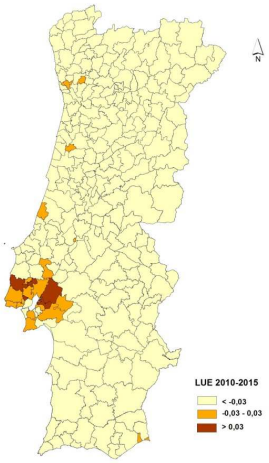
## Results

The results obtained for 2010-2015 show that the LUE-S estimates do not differ from the estimates LUE-P. Therefore, the spatial distribution of LUE-S and LUE-P is analogous.

**Negative values of LUE** indicate that urban soil consumption was faster than urban population growth in the period under review.

• **Values of LUE around zero** indicate that the soil consumption per capita was stable over the period under review (i.e. the urban surface and the urban population increased or decreased both at the same rate).

• **Positive values of LUE** indicate that urban soil consumption was slower than urban population growth in the period under review.




**LUE-S and LUE-P estimates per municipality for 2010–2015**

**Comparison of LUE-S and LUE-P estimates for the period 2010-2015**

| | LUE-S | LUE-P |
|---|---|---|
| Mainland Portugal | -0,10 | -0,10 |
| Minimum per municipality | -1,30 | -1,30 |
| Municipality Median | -0,13 | -0,13 |
| Municipality Mean | -0,16 | -0,16 |
| Maximum per municipality | 0,12 | 0,12 |
| % of Municipalities with LUE > 0 | 5,4 | 5,4 |
| % of Municipalities with LUE = 0 | 0 | 0 |
| % of Municipalities with LUE < 0 | 94,6 | 94,6 |

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## Conclusions

- The differences between the LUE-S and LUE-P estimates for the period 2010–2015 were not significant because the assumption P just enabled the allocation of a very small number of inhabitants (≈3500) to non-urban areas. The proportion of the Mainland population allocated, in 2010 and 2015, to non-urban areas was only 0.03%.
- Given that the criterion used to allocate population to non-urban areas (complex cultivation patterns) was considered too low (population density ≤1.6 inhabitants/$Km^2$), presented results should be faced as preliminary.
- The differences between the LUE-S and LUE-P estimates may become significant if a larger number of inhabitants is allocated to non-urban areas. Therefore, a sensitivity analysis is required to clarify how the differences between LUE-S and LUE-P vary with different criteria for allocating inhabitants to non-urban areas.

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## Conclusions

- Given the decrease of the Mainland population and the urban population of most municipalities in the period 2010-2015, the widespread expansion of the national urban areas is not fully understood, requiring a more in-depth analysis of its growth patterns and inherent processes. Such analysis must be carried out at the municipality level, which is the level at which urban planning policies are defined.
- In those municipalities whose urban population showed a growth trend, decision-makers need to be made aware of the need to implement sustainable land use policies to control urban sprawl.

## References


Corbane, C.; Politis, P.; Siragusa, A.; Kemper, T.; Pesaresi, M. (2017). LUE User Guide: A Tool to Calculate the Land Use Efficiency and the SDG 11.3 Indicator with the Global Human Settlement Layer; Publications Office of the European Union: Luxembourg; ISBN 978-92-79-73631-5, 978-92-79-73630-8, doi:10.2760/16919, 10.2760/212689, JRC108026.

Nicolau, R.; David, J.; Caetano, M.; Pereira, J.M.C. (2019). Ratio of Land Consumption Rate to Population Growth Rate—Analysis of Different Formulations Applied to Mainland Portugal. ISPRS International Journal of Geo-Information; 8(1):10.

UN-Habitat. (2018). Sustainable Development Goal 11+ Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable: A Guide to Assist National and Local Governments to Monitor and Report on SDG Goal 11+ Indicators. Monitoring Framework—Definitions—Metadata—UN-Habitat Technical Support.


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## Information provided by alternative data sources

| COS2015_level3 | Inhabitants (2011) | Inhabitants/Km2 (2011) | % of Mainland population (2011) | Urban land cover classes |
|---|---|---|---|---|
| 1.1.1 Continuous urban fabric | 5521252 | 5302.9 | 54.95 | |
| 1.1.2 Discontinuous urban fabric | 3685255 | 1897.7 | 36.68 | |
| 2.4.2 Complex cultivation patterns | 293252 | 113.5 | 2.92 | |
| 1.2.1 Industrial and commercial units and general infrastructure | 140833 | 218.9 | 1.40 | |
| 2.1.2 Irrigated arable land | 88114 | 22.2 | 0.88 | |
| 2.2.3 Olive groves | 41758 | 9.7 | 0.42 | |
| 2.4.3 Agriculture with natural and semi-natural vegetation | 35046 | 29.9 | 0.35 | |
| 2.1.1 Non-irrigated arable land | 34978 | 4.8 | 0.35 | |
| 3.1.1 Broad-leaved forests | 34566 | 1.6 | 0.34 | |
| 2.4.1 Arable land and/or pastures associated with permanent crops | 30147 | 40.9 | 0.30 | |
| 3.1.2 Coniferous forests | 24600 | 1.9 | 0.24 | |
| 2.2.1 Vineyards | 21584 | 11.6 | 0.21 | |
| 2.2.2 Orchards | 17443 | 18.8 | 0.17 | |
| 3.2.2 Shrublands | 17098 | 1.5 | 0.17 | |
| 1.4.2 Sports, leisure and cultural facilities, and historic zones | 9566 | 76.8 | 0.10 | |
| 3.2.1 Natural herbaceous vegetation | 9278 | 6.8 | 0.09 | |
| 2.3.1 Permanent pastures | 9015 | 2.1 | 0.09 | |
| 1.3.3 Construction sites | 7728 | 58.5 | 0.08 | |
| 1.2.2 Road and rail network and associated land | 7026 | 18.5 | 0.07 | |
| 2.4.4 Agro-forestry systems (AFS) | 3745 | 0.5 | 0.04 | |
| 1.4.1 Green urban areas | 3281 | 76.7 | 0.03 | |
| 1.3.2 Waste disposal areas | 873 | 52.5 | 0.01 | |
| 1.3.1 Mineral extraction sites | 738 | 4.2 | 0.01 | |
| 1.2.3 Port areas | 299 | 17.7 | 0.00 | |
| 3.3.1 Beaches, dunes and sand plains | 243 | 2.5 | 0.00 | |
| 3.3.3 Sparsely vegetated areas | 102 | 0.2 | 0.00 | |
| 4.2.2 Salines and coastal aquaculture | 97 | 1.7 | 0.00 | |
| 1.2.4 Airports | 86 | 2.1 | 0.00 | |

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## Formulas

The LUE formula adapted by Corbane et al. measures the change rate of the built-up area per capita :

$$Idx_t = \frac{Y_t - Y_{t+n}}{Y_t}$$

where

$$Y_t = \frac{BU_t}{Pop_t} \qquad Y_{t+n} = \frac{BU_{t+n}}{Pop_{t+n}}$$

$BU_t$ = Surface occupied by built-up at the initial year (t)
$Pop_t$ = Total population within the built-up area at the initial year (t)
$BU_{t+n}$ = Surface occupied by built-up at the final year (t+n)
$Pop_{t+n}$ = Total population within the built-up area at the final year (t+n)

In order to ensure the comparability of the results at different time intervals, it is recommended to normalize the values of  to obtain a 10-year average change. This is achieved by multiplying the indicator by 10, divided by the number of years between the two observations (n).

$$Idx_{t\pm10} = \frac{Y_t - Y_{t+n}}{Y_t} \times \frac{10}{n}$$

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