TÉCNICO LISBOA

Drivers of Urban Sprawl in Portuguese Medium Cities between 2001 and 2011

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INTRODUCTION

I. Much more complex than a simple oil spill form of urban growth. According with Anderson et al (1996) four fundamental aspects define sprawl:
   I. Expansion to the exterior of the boundaries between urban and rural areas;
   II. General decline of both densities and intensities of urban use;
   III. The existence of transport networks providing high levels of connectivity;
   IV. Segregation between different types of land use, leading to situations where the majority of housing is in the suburbs.

II. Urban sprawl allows an unarticulated, discontinuous and polycentric urban growth, juxtaposing freeways, malls, high rise buildings and detached houses (Graham e Marvin, 2001).

OBJECTIVES AND CASE STUDY

I. Urban Sprawl is assumed to be responsible for a series of negative impacts

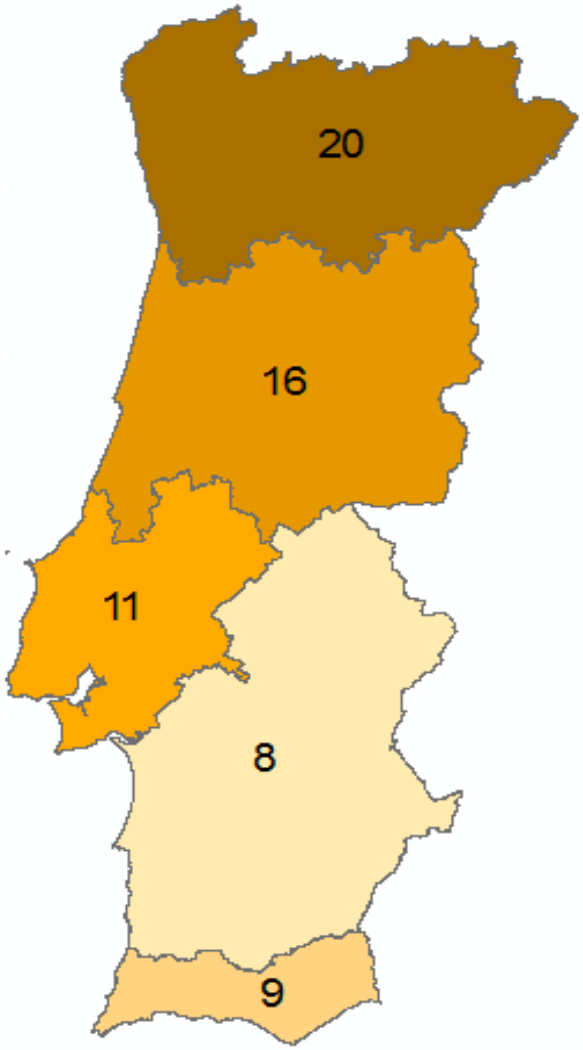
II. Measuring the levels of urban sprawl between 2001 and 2011 in 64 Portuguese medium cities (excluding the metropolitan areas of Lisbon and Oporto).

III. Taking in account the multidimensionality of sprawl by building five urban sprawl indicators (density, growth in urbanized area, fragmentation, dispersion and irregularity)

IV. Explain the role of different drivers of urban sprawl : socioeconomic structure, geographic /physical aspects, public policies, accessibility /mobility on sprawl and past evolution

CONTEXT

Position (dimension)	NUT II	Number of Cities
1	Alentejo	8
2	Centro	16
3	Norte	20
4	Lisboa e Vale do Tejo	11
5	Algarve	9



DEFINITION OF URBAN SPACE

- We used statistical sub-sections (equivalent to census block) and data extracted from the census of 1991, 2001 and 2011
- Sub-sections with more than 700 dwellings/Km^2 **OR** with more than 2000 inhabitants/Km^2
- Union of all sub-sections with the previous definitions
- Agglomeration of separated urban sub-sections up to a distance of 400 meters with the inclusion of non urban sub-sections in between
- Creation of central and secondary urban areas
- Elimination of interstices inside both urban areas

DEFINITION OF URBAN SPRAWL

- Definition of sprawl with five indicators:
  - Increase of urban expansion

$$\Delta E_i = \Delta A_{i_{2011/2001}} - \Delta Pop_{i_{2011/2001}}$$

A – Urban Area

P – Population

  - Density

A – Urban Area

Pop – Population

Aloj - Dwellings

$$d_{b_i} = \frac{Pop_i}{A_i} \qquad D_{b_i} = \frac{Aloj_i}{A_i} \qquad \Delta D_i = \frac{D_{i_{2011}}}{D_{i_{2001}}}$$

  - Fragmentation

A_{nc} – *Non Central Urban Area*

A – Urban Area

$$F_i = \frac{A_{nc\,i}}{A_i} \qquad \Delta F_i = F_{i_{2011}} - F_{i_{2001}}$$

DEFINITION OF URBAN SPRAWL

- **Dispersion**

$$Dps_i = \sum \frac{A_{nc_{ij}}}{A_{c_i}} \times d_j$$

$$\Delta Disp_i = Disp_{i_{2011}} - Disp_{i_{2001}}$$

$\sum \frac{A_{nc_{ij}}}{A_{c_i}}$ – *Sum of the Non Central Urban Areas by the Central Urban Areas Product*

dj – Distance between the two area types' centroids, minus the radius of two circles with equivalent area to the considering areas

- **Irregularity**

$$I_i = \frac{P_{c_i}}{P_{0_i}} = \frac{P_{c_i}}{2\sqrt{\pi A_{c_i}}}$$

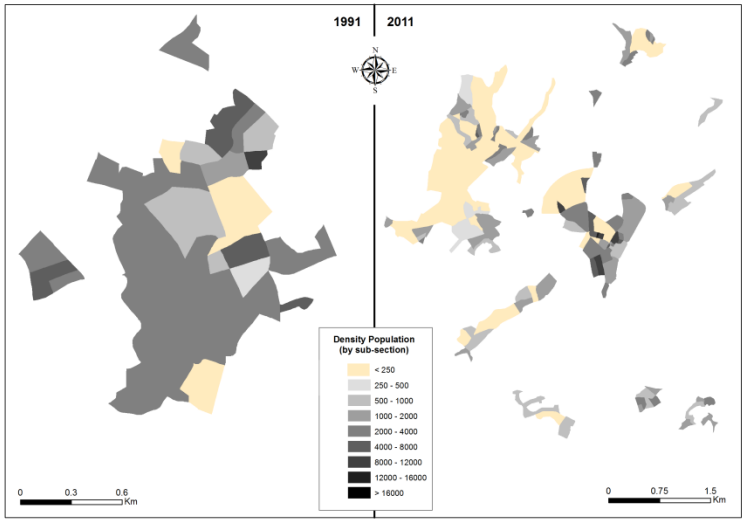
$$\Delta I_i = \frac{I_{i_{2011}}}{I_{i_{1991}}}$$

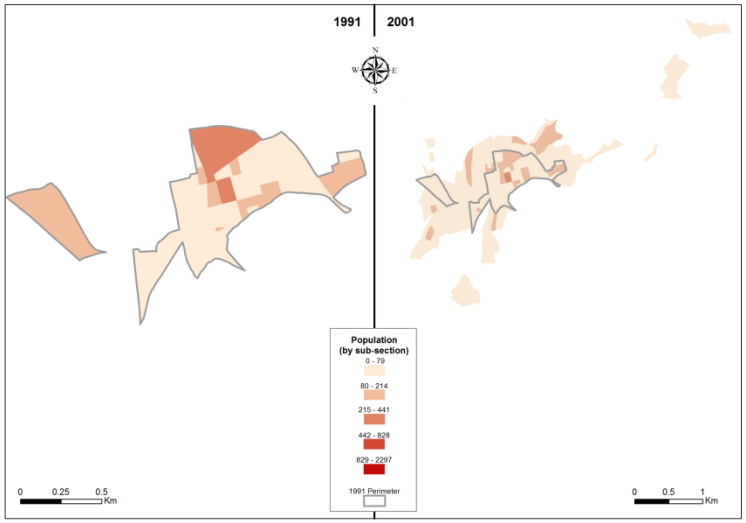
P_{c_i} - *Official Center Perimeter*

A_{c_i} - *Central Urban Area*

Defining the urban boundaries (I)

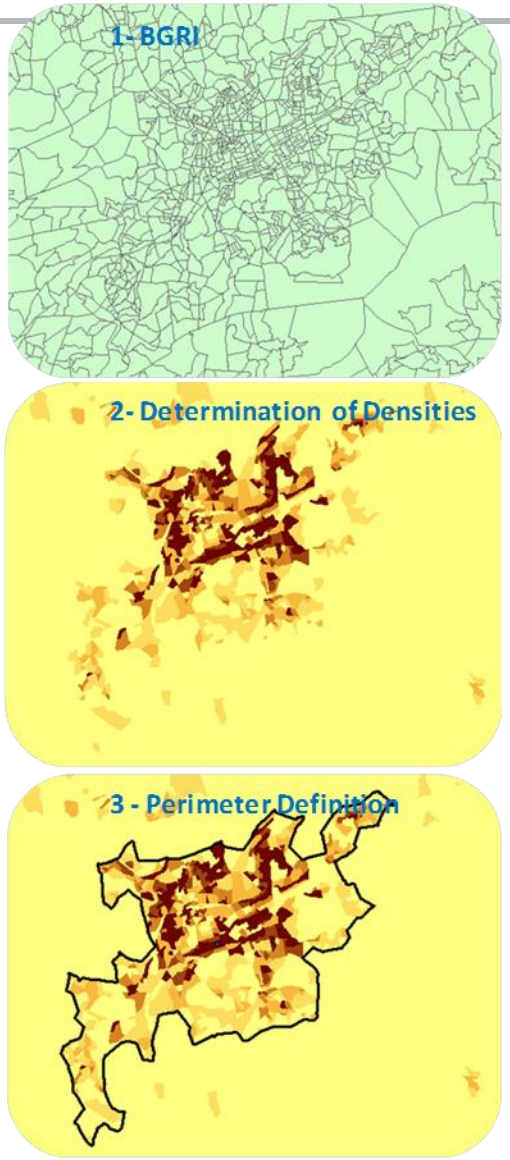
- This study uses three types of urban perimeters:
- The official urban perimeter. Sometimes includes vast areas not yet urbanized and could be more or less similar to the actual city limits.
- Three urban perimeters (1991, 2001 and 2011) based on Census data, using thresholds of minimum density of population (20 inhab/ha) or housing units (7 h.u./ha), corresponding to the lower limit of urban areas with low density (Costa Lobo et al, 1995)





Defining the urban boundaries (II)

- Rules for the definition of the urban areas in both periods :
- Union of all the contiguous statistical subsections with densities equal or above the defined thresholds;
- All the non contiguous statistical subsections with densities equal or above the thresholds were joined with the urban perimeter whenever the distance among them was equal or below 400 meters.
- Inexistence of empty areas inside the urban area.



SPRAWL EVOLUTION

Indicator	Weighted Average (*Pop* / Area)			Variation (%)	
	1991	*2001*	*2011*	*1991 - 2001*	*2001 - 2011*
Increase of Urban Expansion	-	-	-	19%	38%
Density Population (inhab/km^2)	*4865.22*	*4147.95*	*3319.68*	-14.7%	-20.0%
Fragmentation (ratio)	0.24	0.19	0.17	-20.8%	-10.5%
Dispersion (ratio)	0.326	0.334	0.021	2.5%	-93.7%
Irregularity (ratio)	3.24	4.24	5.07	30.1%	19.6%

DATA AND MODELING APPROACH

We collected data describing several dimensions that where considered to influence sprawl. These dimensions where:

I. *Physical/geographical features - e. g. altitude, irregularity , geographical barriers, bioclimatic comfort, agricultural property structure, proximity to the coast.*

II. *Demography – e.g. population, population density demographic weight in the municipality, population structure (dependency indexes) – values in 2001 and variation 2011 – 2001.*

III. *Socioeconomy - e.g. employment and economic structure by sectors, regional GDP, – values in 2001 and variation 2011 – 2001.*

IV. *Policy – ratio of the urban arear versus the official urban perimeter - 2001;*

V. *Accessibility/Mobility – Accessibility (intervening opportunities), commuting spatial distribution and mode choice – values in 2001 and variation 2011 – 2001.*

VI. *Past evolution – values of the sprawl indicators for 2001-1991, demography 1991-2001.*

The modeling approach was OLS stepwise linear regression . Results checked for multicollinearity, normally distributed residuals and visual inspection of heteroskedasticity

RESULTS (Increase of Urban Expansion)

$$\Delta E_i = \Delta A_{i_{2011/2001}} - \Delta Pop_{i_{2011/2001}}$$

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.72	0.52	0.48	0.21	1.61

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Constant	-0.3606	0.2785		-1.2947	0.2006		
Ratio urban area/Official Urban Perimeter	0.0073	0.0019	0.3576	3.8566	0.0003	0.9602	1.0415
Population growth 1991-2001	-1.1522	0.2600	-0.4127	-4.4313	0.0000	0.9519	1.0506
Irregularity	0.0047	0.0011	0.3943	4.1276	0.0001	0.9050	1.1050
Dependence index of youngsters	1.9364	0.7468	0.2391	2.5929	0.0120	0.9709	1.0300
Population 30 mins distance (interv. Opportunities) - Var 2011-2001	-0.2038	0.0894	-0.2194	-2.2807	0.0263	0.8920	1.1210

RESULTS (Density)

$$\Delta D_i = \frac{D_{i_{2011}}}{D_{i_{2001}}}$$

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.72	0.51	0.48	0.10	2.10

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Constant	2.018	0.203		9.934	0.000		
Ln(Proximity to the coast)	-0.019	0.009	-0.208	-2.047	0.045	0.795	1.258
Dependence index of youngsters - Var 2001-2011	2.091	0.462	0.426	4.527	0.000	0.930	1.075
Ln(Ratio urban area/Official Urban Perimeter)	-0.129	0.026	-0.633	-4.904	0.000	0.495	2.020
Number of residences - Var. 2001-2011	0.250	0.083	0.390	3.023	0.004	0.495	2.021

RESULTS (Fragmentation)

$$\Delta F_i = F_{i_{2011}} - F_{i_{2001}}$$

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.64	0.41	0.37	0.07	1.89

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Constant	-0.119	0.047		-2.556	0.013		
Fragmentation - Var. 1991-2001	-0.179	0.037	-0.527	-4.814	0.000	0.828	1.207
Ln (Dependence of elderly)	-0.156	0.032	-0.597	-4.948	0.000	0.683	1.464
Tertiary employment - Var. 2001-2011	0.156	0.056	0.317	2.781	0.007	0.766	1.306
Ln (size of agricultural explorations)	-0.027	0.010	-0.325	-2.765	0.008	0.718	1.392

RESULTS (Dispersion)

$$\Delta Disp_i = Disp_{i_{2011}} - Disp_{i_{2001}}$$

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.64	0.42	0.35	0.48	1.67

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Constant	0.145	0.975		0.148	0.883		
Municipal Population - Var 1991 - 2001	1.805	0.674	0.313	2.677	0.010	0.748	1.336
Commuting walk share - var 2001 - 2011	1.729	0.500	0.357	3.456	0.001	0.960	1.042
College degree - Var. 2001-2011	-0.633	0.187	-0.388	-3.381	0.001	0.781	1.281
Dependence index of youngsters	8.221	2.376	0.492	3.461	0.001	0.507	1.972
Dependence index of youngsters - Var 2001-2011	6.263	3.032	0.293	2.066	0.043	0.509	1.965
Number of commuters working in a different municipality	0.000	0.000	0.216	2.059	0.044	0.934	1.070

RESULTS (Irregularity)

$$\Delta I_i = \frac{I_{i_{2011}}}{I_{i_{1991}}}$$

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.75	0.56	0.51	0.09	1.75

Varables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Constant	1.085	0.201		5.398	0.000		
Ln(Ratio urban area/Official Urban Perimeter)	0.091	0.017	0.497	5.500	0.000	0.945	1.058
Ln(Dependence index of youngsters)	0.738	0.136	0.567	5.413	0.000	0.701	1.426
Irregularity	0.002	0.000	0.348	3.752	0.000	0.893	1.120
Population 30 mins distance (interv. Opportunities) - Var 2011-2001	-0.123	0.039	-0.311	-3.154	0.003	0.793	1.260
Ln(Irregularity sprawl - Var 1991 - 2001)	-0.241	0.073	-0.358	-3.292	0.002	0.653	1.532
Ln(ratio college degree)	0.076	0.034	0.243	2.248	0.028	0.657	1.523

CONCLUSIONS (I)

I. Sprawl levels have increased in these past two decades.

II.The relations between different sprawl dimensions are complex and not immediately intuitive, e.g. a decrease in fragmentation could be due to an increase in the urban area (linking the central area with the former urban secondary urban areas) and a reduction in density.

CONCLUSIONS (II)

IV.The models built, although preliminary, highlight some relevant relations and policy conclusions:

- Accessibility increase (pop at *x* mins distance) contributes to reducing sprawl.
- Having bigger official urban perimeters (compared with the urbanized areas) will increase sprawl levels, highlighting the importance of urban growth boundaries.
- Geographical characteristics do count on sprawl as well as previous evolution.
- Some dimensions of sprawl are also influenced by population growth and with economic dimensions.
- The characteristics of agricultural explorations influence sprawl as an increase in its number reduces several dimensions of sprawl.
- Commuting patterns where found as not strongly influencing sprawl, which might be due to a more complex causal relations between both.

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Thank You for Your Attention!