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“Urban form revisited - selecting indicators for characterising european cities”

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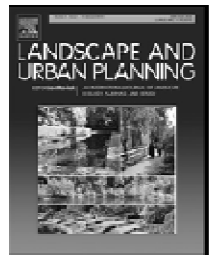

Urban form revisited—Selecting indicators for characterising European cities

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A B S T R A C T

Four out of five European citizens life in urban areas, and urban form – like the density or compactness of a city – influences daily life and is an important factor for both quality of life and environmental impact. Urban planning can influence urban form, but due to practicality needs to focus on a few indicators out of the numerous indicators which are available. The present study analyses urban form with respect to landscape metrics and population-related indicators for 231 European cities. Correlations and factor analysis identify the most relevant urban form indicators. Furthermore, a cluster analysis groups European cities according to their urban form. Significant differences between the clusters are presented. Results indicate that researchers, European administration and urban planners can select few indicators for analysing urban form due to strong relationships between single indicators. But they should be aware of differences in urban form when comparing European cities or working on planning policies for the whole of Europe.

O que é “forma urbana”

Urban form reveals the relationship between a single city and its rural hinterland (Grimm et al., 2008) as well as the impact of human actions on the environment within and around a city (Alberti, 2005; Environmental Protection Agency, EPA, 2001; Weng et al., 2007). This also relates to transportation patterns (Dieleman and Wegener, 2004). An ongoing debate distinguishes between the “urban sprawl” often found in North American cities versus the idealised, European “compact city” as two opposite urban forms (Dieleman and Wegener, 2004; Frenkel and Ashkenazi, 2008).

[p. 29]

- relationship between a single city and its rural hinterland
- impact of human actions on the environment within and around a city
- transportation patterns

“urban sprawl” often found in North American cities

versus

the idealised, European “compact city”

O que é “forma urbana”

The definitions of urban form vary to a great extent in the literature. While some authors solely rely on land use/land cover to measure urban form in terms of the physical structure of a city (Herold et al., 2002; Huang et al., 2007), others also include socio-economic aspects such as population number or density (Frenkel and Ashkenazi, 2008; Kasanko et al., 2006; Tsai, 2005). Furthermore, the question of whether the sheer size of a city is one aspect of urban form (e.g. Tsai, 2005) or an independent indicator (Batty, 2008; Huang et al., 2007) is still open. However, urban form itself is mainly referred to as a property of a city and therefore static for a given point in time, while urban growth is a dynamic process that alters urban form.

For this paper, the broadest definition possible of urban form is used. Accordingly, urban form here encompasses the physical structure and size of the urban fabric as well as the distribution of population within the area. Urban form of a specific city is the result of a variety of influences, including site and topography, economic and demographic development and planning efforts in the past (Batty and Longley, 1994).

[p. 30]

- land use/land cover
- socioeconomic aspects (population number or density)
- size of a city: aspect of urban form or an independent indicator ?

result of a variety of influences, including site and topography, economic and demographic development and planning efforts in the past

Physical structure and size of the **urban fabric** and the distribution of **population**

A análise da forma urbana

An analysis of urban form reveals the problems and challenges of urban development. From a policy point of view, this is necessary to identify areas with a high need of policy intervention and to determine the diversity of urban developments. In the following, the relevance of urban form in European policies is highlighted.

- identify areas with a high need of policy intervention
- determine the diversity of urban developments

- Aalborg Charter of European Cities and Towns Towards Sustainability – 1994
- European Spatial Development Perspective – 1999
- European Spatial Planning Observation Network – 2002 Thematic Strategy on the Urban Environment – 2006
- Cohesion policy – 2006
- Leipzig Charter on Sustainable European Cities – 2007
- Territorial Agenda – 2007
- European Urban Charter II – 2008

A quantificação da forma urbana

(a) 26 Landscape metrics

- Size of continuous area [area cont]
- Size of discontinuous area [area discont]
- Size of total area [area total]
- Size of sealed urban area [area urban]
- Area weighted mean patch fractal dimension [AWMPFD - MPFD]
- Area weighted mean shape index [AWMSI]
- Centrality index [centrality]
- Compactness index [CI]
- CI of the largest patch [CILP]
- Share of continuous/residential land [cont/resid]
- Share of continuous/urban land [cont/urban]
- Edge density [ED]
- Median patch size [MDPS]
- Mean perimeter-area ratio [MPAR]
- Mean patch edge [MPE]
- Mean patch size [MPS]
- Number of patches [NP]
- Patch size coefficient of variance [PSCV]
- Patch size standard deviation [PSSD]
- Porosity [ROS]
- Total edge [TE]
- Share of sealed urban area [urban/area]
- Contagion index
- Density of building
- Fractal dimension
- Proportion of detached/semi-detached

Quantificação da forma urbana

(b) 18 Socioeconomic indicators

- Index of Dissimilarity in population distribution [diss2]
- Dwelling number [dwell]
- Gini coefficient of population distribution [Gini2]
- Household number [hh]
- Density of housing [hh/area]
- Density of housing in urban land [hh/urban]
- Population number [pop]
- Density of population [pop dens]
- Density of population in urban land [pop dens urban]
- Sealed urban area per person [urban/capita]
- Car availability [cars]
- GDP per capita [GDP/capita]
- Proportion higher education [prop high education]
- IT availability [PC in hh] [www in hh]
- Density of addresses
- Density of buildings with addresses
- Mix of use
- Moran coefficient (high-density Districts)

Metodologia – dados utilizados

- Socio-economic data from the Urban Audit reporting period of 2003/2004 for the years 1999–2002.

  231 cities provided data relevant for this study and were therefore included in the analysis.

- Data on **administrative boundaries** for cities participating in Urban Audit were downloaded from the Eurostat website.

- Land cover information from CORINE Land Cover (CLC) project.

  Raster data with a **resolution of 100 per 100 meters** for land cover in Europe 2000.

Metodologia – preparação dos dados

Data preparation

P1. Urban Audit administrative boundaries of cities were revised. **Distinct polygons for the same city were merged** if these features were separated by small water bodies, roads et cetera. **Polygons with holes were filled up**.

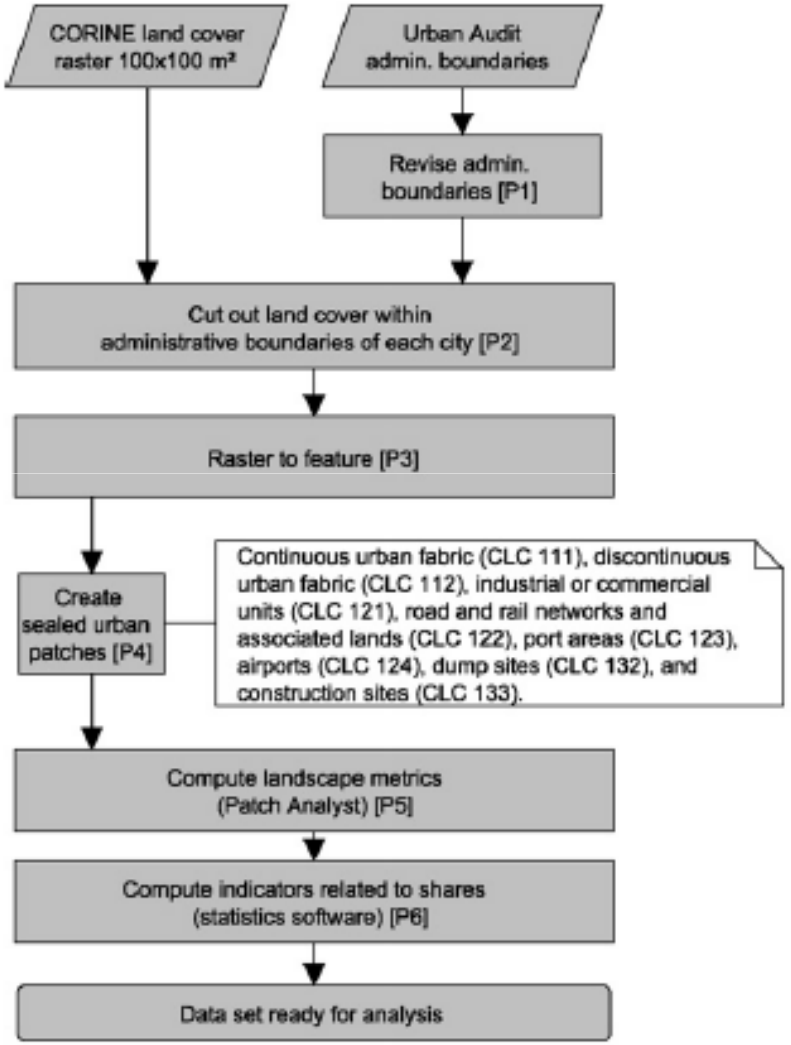
P2. Administrative boundaries were used to cut out CORINE land cover raster data.

P3. These raster data were converted into features.

P4. The **CLC classes were merged into a single class of "sealed urban patches"**. This procedure of summarising urban land covers into a single category for analysis is in line with other research on urban form.

P5. **Landscape metrics for this urban class were computed** using the open source software "Patch Analyst". Patch Analyst is an extension for the ArcGIS® Software and provides the most common landscape metrics for landscape analysis. Landscape metrics were computed using the class level procedure and the joined sealed urban area as input. Class level procedure implies referring to the sealed urban patches only and not to all patches in the city.

P6. Additionally, ratios like the share of sealed urban patches compared to the size of the whole city as well as Index of Dissimilarity and Gini-coefficient were computed. The latter two were computed for Urban Audit SCD level 2 (sub-districts possibly created for Urban Audit to be more comparable).



Metodologia - análise

Analysis

A1. Linear correlations among (1) population-related and (2) landscape metrics as well as (3) with both were computed to reveal similarities. Spearman's Rho *rs* was used as **correlation measure**.

A2. To reduce the number of indicators entering the factor analysis, indicators of urban form were omitted from further analysis, if they show strong correlations (absolute correlations >.8).

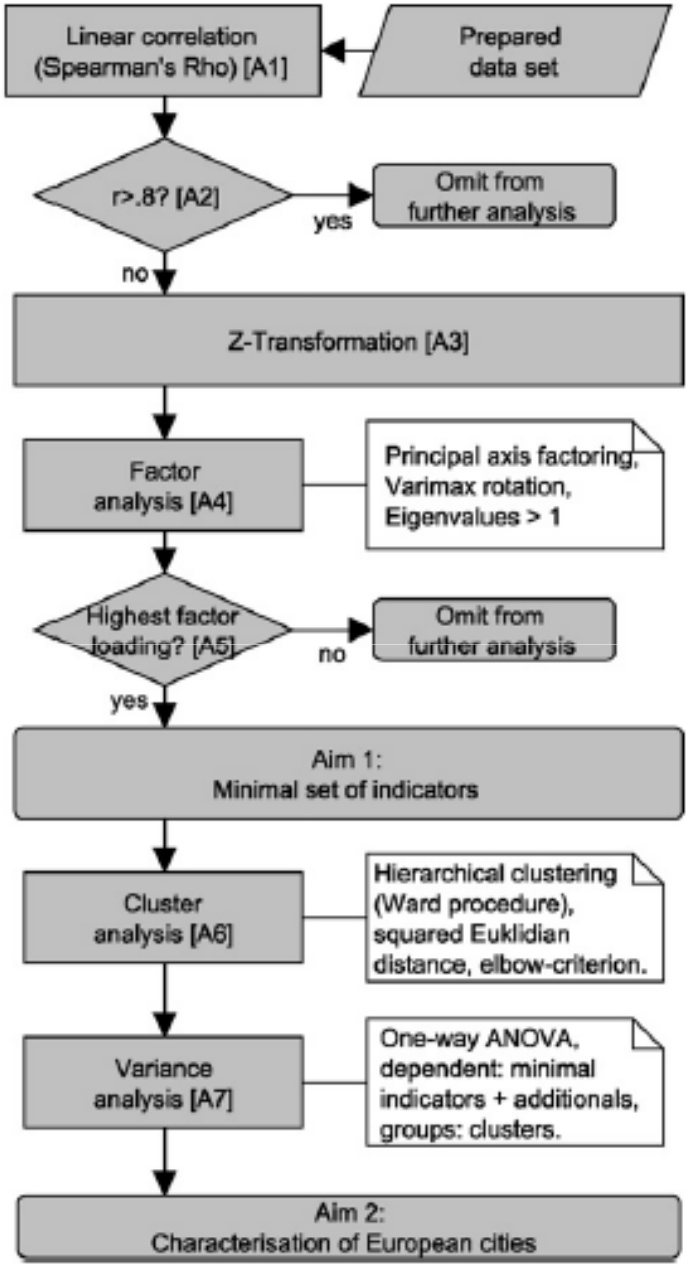
A3. All variables were normalised (Z-transformation) - mean for each indicator equals 0 and the standard deviation equals 1.

A4. A **factor analysis** was computed.

A5. Indicators which best represent the extracted factors are included into the minimal indicator set for urban form.

A6. The **hierarchical clustering** (Ward procedure) was applied with the squared Euclidian distance. The "elbow-criterion", which focuses on the percentage of variance explained as a function of the number of clusters, determined the number of clusters. According to this rule of thumb the optimal number of clusters is the number after which the marginal gain of adding one more cluster drops sharply.

A7. To characterise the cities belonging to each cluster, **a one-way analysis of variance** was computed, using the minimal indicator set as dependent variables. Additionally, socio-economic indicators were used as dependent variables to gain an impression of the various aspects of human welfare in these clusters: GDP per capita, proportion of population with higher education, car ownership per 1000 inhabitants, PC and Internet availability in households.



Resultados – análise de correlação

Correlations among socio-demographic indicators and landscape metrics respectively.

Area total	Area urban	Urban/ area	Discont	Cont	Cont/ urban	Cont/ resid	ROS	AWMSI	MSI	MPAR	MPFD	AWMPFD	TE	ED	MPE	MPS	NP	MDPS	PSCOV	PSSD	CILP	CI	Centrality	
1.00	.64***	−.37***	.57***	.26**	−.05	−.03	.37***	.37***	−.13	−.04	−.05	.31***	.80***	−.45***	−.18**	−.18**	.76***	−.01	.58***	.13	−.36***	−.77***	.24***	Area total
	1.00	.40***	.91***	.35***	−.13	−.12	−.40***	.65***	−.04	.23***	.15	.35***	.88***	.16	.29***	.40***	.56***	−.21**	.66***	.74***	−.31***	−.56***	.04	Area urban
		1.00	.37***	.19**	−.01	−.04	−1.00***	.29***	.09	.36***	.25***	.00	.06	.76***	.60***	.74***	−.27***	−.25***	.03	.72***	.08	.28***	−.27***	Urban/area
			1.00	.11	−.33***	−.34***	−.37***	.68***	.03	.19**	.14*	.39***	.82***	.18**	.31***	.39***	.50***	−.16*	.61***	.70***	−.34***	−.50***	−.03	Discont
Area total (UA)	1.00			1.00	.85***	.85***	−.19***	.19**	−.05	.11	.05	.06	.26***	.01	.12	.20**	.16*	−.13*	.23***	.30***	−.10	−.16*	.00	Cont
hh	.50***	1.00			1.00	1.0***	.01	−.10	−.04	.04	.03	−.08	−.16**	−.09	−.02	.00	−.10	−.09	−.07	−.05	.05	.10	.00	Cont/urban
Dwell	.51***	.99***	1.00			1.00	.04	−.11	−.05	.03	.02	−.00	−.14*	−.10	−.05	−.02	−.07	−.08	−.06	−.07	.05	.07	.02	Cont/resid
Pop	.49***	.99***	.99***	1.00			1.00	−.29***	−.09	−.36***	−.25***	.00	−.06	−.76***	−.60***	−.74***	.27***	.25***	−.03	−.72***	−.08	−.28***	.27***	ROS
Popdens (UA)	−.34***	.60***	.58***	.58***	1.00			1.00	.21**	.29***	.35***	.89***	.67***	.34***	.34***	.26***	.36***	−.29***	.66***	.59***	−.45***	−.36***	.01	AWMSI
Popdens	−.30***	.60***	.58***	.58***	.97***	1.00			1.00	−.35***	−.03	.28***	−.04	.16	.62***	.36***	−.37***	.43***	−.38***	.18**	−.14	.34***	−.14	MSI
Popdens Urban	−.15	.28***	.32***	.36***	.55***	.57***	1.00			1.00	.87***	.22***	.15	.31***	−.11	.03	.18**	−.86***	.36***	.23***	−.03	−.15	−.03	MPAR
Urban/capita	.15	−.28***	−.32***	−.36***	−.55***	−.57***	−1.00***	1.00			1.00	.38***	.16	.33***	−.11	−.07	.19**	−.74***	.33***	.12	−.14	−.17**	−.03	MPFD
hh/area	−.23***	.64***	.63***	.63***	.95***	.98***	.50***	−.50***	1.00			1.00	.54***	.26***	.12	−.06	.37***	−.24***	.56***	.22***	−.48***	−.39***	.07	AWMPFD
hh/urban	−.10	.45***	.46***	.46***	.63***	.65***	.91***	−.91***	.65***	1.00			1.00	.06	−.01	.01	.82***	−.16	.78***	.40***	−.44***	−.83***	.16	TE
diss2	.45***	.00	.00	.04	−.38***	−.29**	−.17	.17	−.35***	−.31***	1.00			1.00	.29***	.30***	−.09	−.22***	.11	.31***	−.02	.10	−.17**	ED
Gini2	.09	.02	.06	.01	−.10	−.11	−.10	.10	−.05	−.03	−.09	1.00			1.00	.93***	−.53***	.22***	−.30***	.73***	.00	.52***	−.26***	MPE
	Area total (UA)	hh	Dwell	Pop	Popdens (UA)	Popdens	Popdens urban	Urban/capita	hh/area	hh/urban	diss2	Gini2				1.00	−.48***	.08	−.20**	.85***	.09	.49***	−.26***	MPS
																	1.00	−.22***	.81***	−.07	−.36***	−1.00***	.27***	NP
																		1.00	−.41***	−.15	.04	.19**	−.03	MDPS
																			1.00	.27***	−.38***	−.80***	.18**	PSCOV
																				1.00	−.12	.07	−.17**	PSSD
																					1.00	.38***	.37***	CILP
																						1.00	−.26***	CI
																							1.00	Centrality

* $p < 0.5$.
** $p < .01$.
*** $p < .001$.

Resultados – análise de correlação

Correlations between landscape metrics and population-related indices (Spearman's Rho).

	Area total	Area urban	Urban/ area	Discont	Cont	Cont/ urban	Cont/ resid	ROS	AWMSI	MSI	MPAR	MPFD	AWMPFD	TE	ED	MPE	MPS	NP	MDPS	PSCOV	PSSD	CLUMP	CI	Centrality
Area total (UA)	.97***	.62***	−.30***	.55***	.36***	.08	.10	.30***	.36***	−.12	−.06	−.07	.30***	.79***	−.35***	−.16	−.15	.74***	.30	.55***	.14	−.36***	−.74***	.23***
hh	.45***	.88***	.55***	.74***	.49***	.07	.07	−.55***	.56***	−.05	.24***	.10	.23***	.70***	.25***	.39***	.53***	.38***	−.20**	.53***	.78***	−.24***	−.37***	−.07
Dwell	.48***	.88***	.49***	.73***	.52***	.15*	.15*	−.49***	.56***	−.08	.29***	.17	.26***	.73***	.22**	.31***	.46***	.44***	−.27***	.60***	.74***	−.30**	−.42***	.02
Pop	.44***	.86***	.50***	.69***	.54***	.14*	.14*	−.50***	.54***	−.05	.25***	.12	.24***	.68***	.21**	.34***	.48***	.37***	−.22***	.52***	.73***	−.25***	−.36***	−.06
Pop dens (UA)	.34***	.35***	.86***	.29***	.28***	.11	.08	.86***	.28***	.00	.37***	.24***	.00	.03	.60***	.52***	.68***	.24***	.31***	.07	.68***	.02	.26***	.32***
Pop dens	−.39***	.31***	.88***	.23**	.33***	.20**	.17*	−.88***	.23***	.06	.32***	.20**	−.02	−.02	.64***	.54***	.68***	−.30***	−.23***	.00	.64***	.04	.31***	−.31***
Pop dens urban	−.22**	−.10	.18**	−.24***	.41***	.48***	.47***	−.18**	−.05	−.03	.07	.00	−.08	−.23***	.03	.15	.19**	−.25***	−.10	−.12	.11	−.02	.26***	−.24***
Urbar/capita	.22*	.10	−.18**	.24***	−.41***	−.48***	−.47***	.18**	.05	.03	−.07	.00	.08	.23**	−.03	−.15	−.19**	.25***	.10	.12	−.11	.02	−.26***	.24***
hh/area	−.32***	.38***	.90***	.31***	.29***	.11	.08	−.90***	.27***	.01	.31***	.17	−.01	.06	.64***	.54***	.69***	−.23***	−.25***	.06	.67***	.05	.24***	−.26***
hh/urban	−.19**	.04	.32***	−.08	.36***	.37***	.36***	−.32***	.02	−.08	.10	−.01	−.07	−.13	.14	.22**	.30***	−.21**	−.12	−.05	.24***	.04	.22**	−.20**
diss2	.37***	.12	−.37***	.08	.20*	.18*	.20*	.37***	.02	.15	−.18	−.04	.11	.30***	−.22	−.19	−.25**	.35***	.19	.21	−.18	−.37***	−.37***	−.09
Gini2	.12	.04	.06	.05	.07	.06	.06	.06	.06	.07	.05	.04	.08	.04	.17	.09	.05	.10	.02	.06	.00	.21**	.09	.30***

- 11 landscape metrics and 5 socioeconomic indicators were selected.

Resultados – análise fatorial

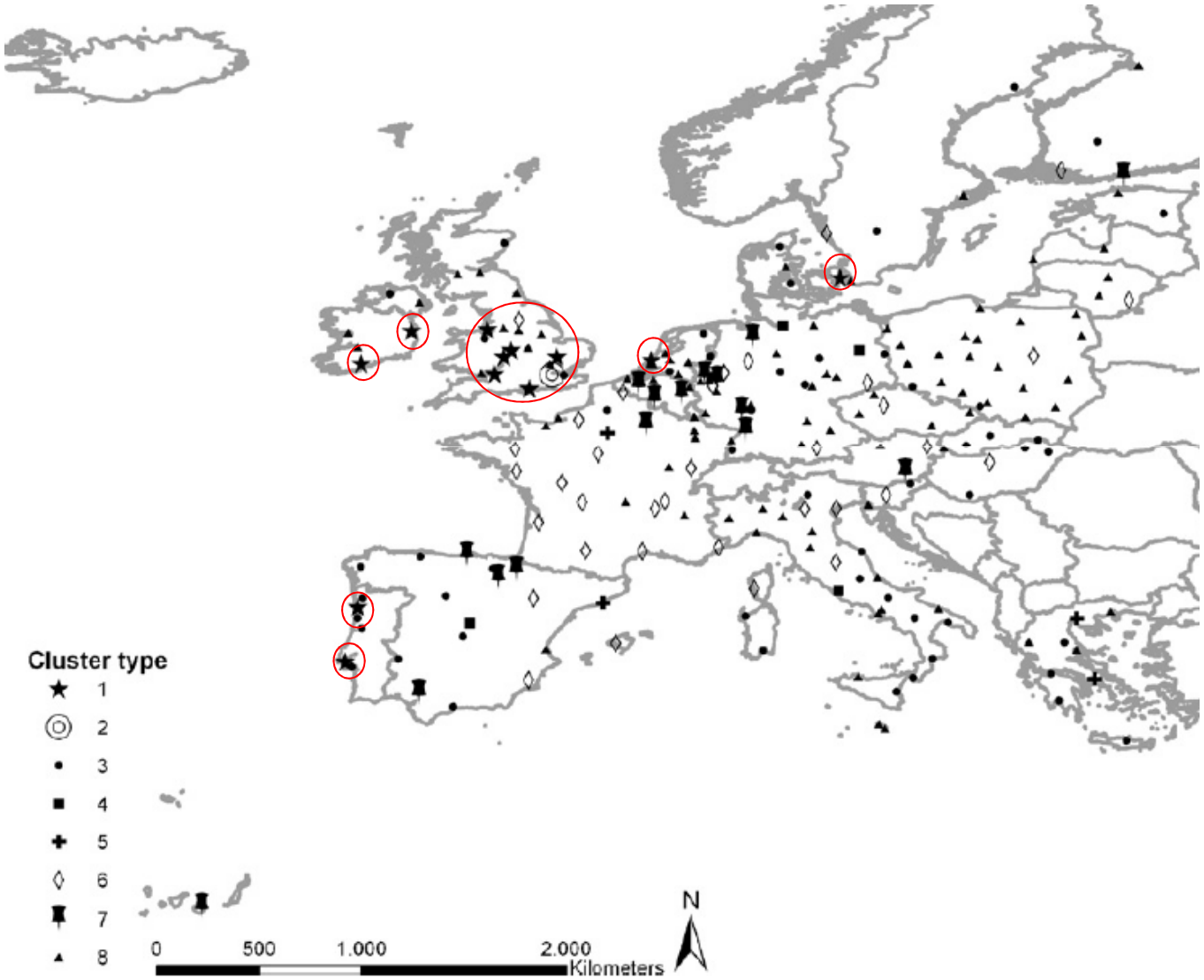
Factors extracted by factor analysis.

	Factor						Communalities
	I	II	III	IV	V	VI	
	% of variance						
	22	12	10	9	8	5	
Factor loadings							
Area total	0.48	−0.06	−0.01	0.45	−0.52	0.09	0.72
Area cont	0.43	0.72	0.04	0.14	−0.17	0.11	0.76
Area disc	0.92	0.06	0.10	0.04	−0.09	−0.04	0.87
AWMSI	0.80	−0.03	−0.04	0.07	0.24	−0.14	0.73
ED	0.13	0.09	0.10	−0.09	0.83	0.03	0.73
MPS	0.19	0.19	0.82	−0.35	0.03	−0.06	0.86
NP	0.49	−0.08	−0.20	0.67	−0.01	0.11	0.75
MDPS	−0.14	0.07	0.82	0.09	0.07	−0.07	0.72
PSCOV	0.69	−0.03	−0.31	0.46	0.19	0.06	0.83
CILP	−0.22	0.03	0.05	−0.32	−0.02	0.56	0.47
Centrality	0.01	−0.06	−0.05	0.03	0.15	0.35	0.15
Pop	0.84	0.49	0.06	0.04	−0.14	−0.01	0.98
Pop dens	−0.01	0.75	0.34	−0.10	0.24	0.08	0.75
Urban/capita	0.04	−0.67	0.01	0.19	−0.07	0.23	0.55
diss2	−0.01	−0.09	0.00	0.57	−0.17	−0.25	0.42
Gini2	0.02	0.00	−0.04	−0.01	−0.11	0.45	0.22

Factor loadings of principal axis factoring with Varimax rotation.
- Light grey: 0.5 ≤ absolute factor loading <0.7.
- Dark grey: 0.7 ≤ absolute factor loading.

- In the factor analysis, six factors with Eigenvalues greater than one were extracted.
- They explain about 66% of the variance in the overall data set.
- For the minimal set of indicators of urban form, the indicator with the highest factor loading per factor was chosen – **5 metrics and 2 indicators**.

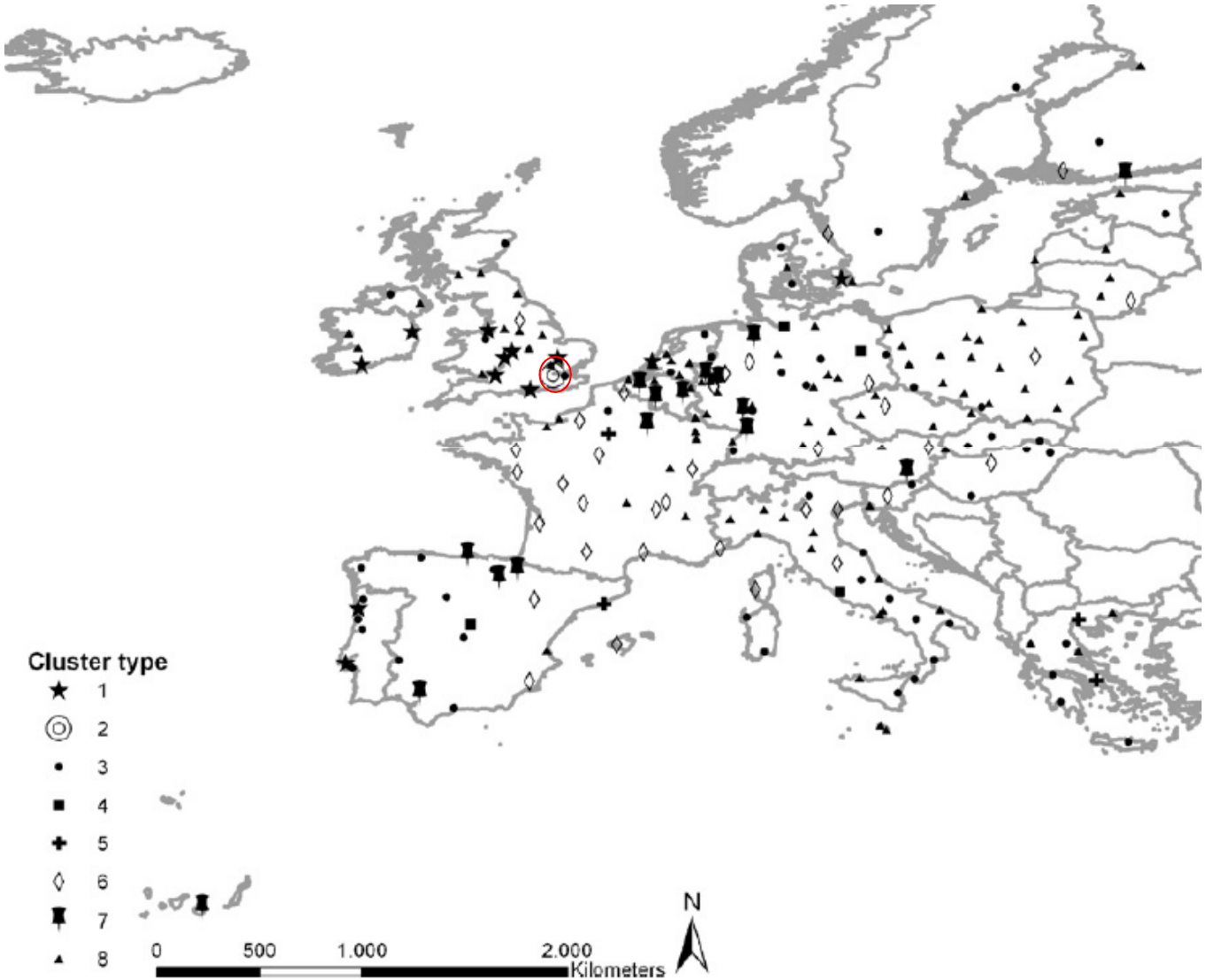
Resultados – clusters



Cluster 1

- Above average mean patch size
- Smaller number of patches
- Higher population density
- Compact development, with several centres as opposed to a single one
- UK and Denmark, Ireland, the Netherlands and Portugal

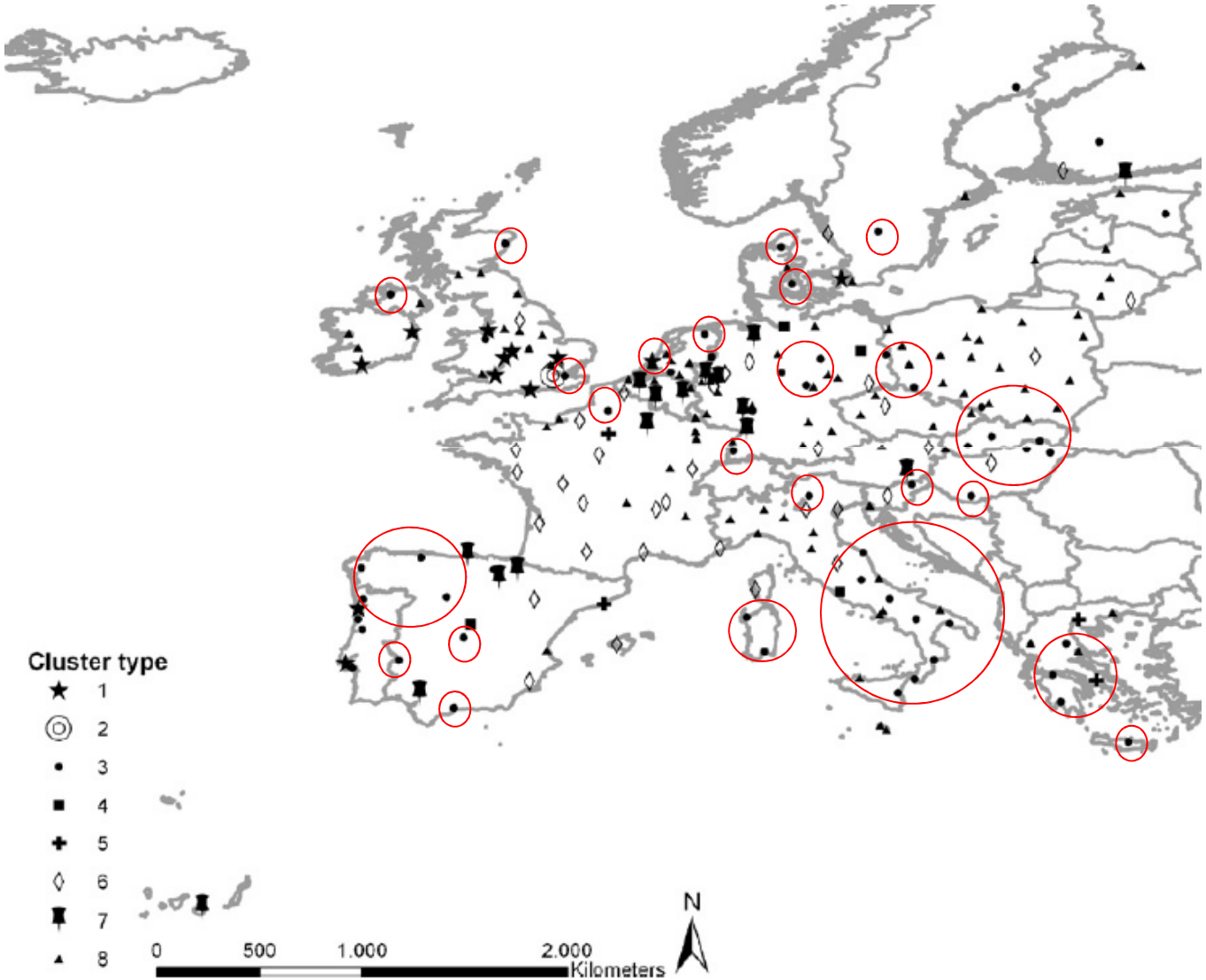
Resultados – clusters



Cluster 2

- Very large area of discontinuous urban fabric
- Large population
- Large mean patch size
- Less than average compactness index of the largest patch
- London

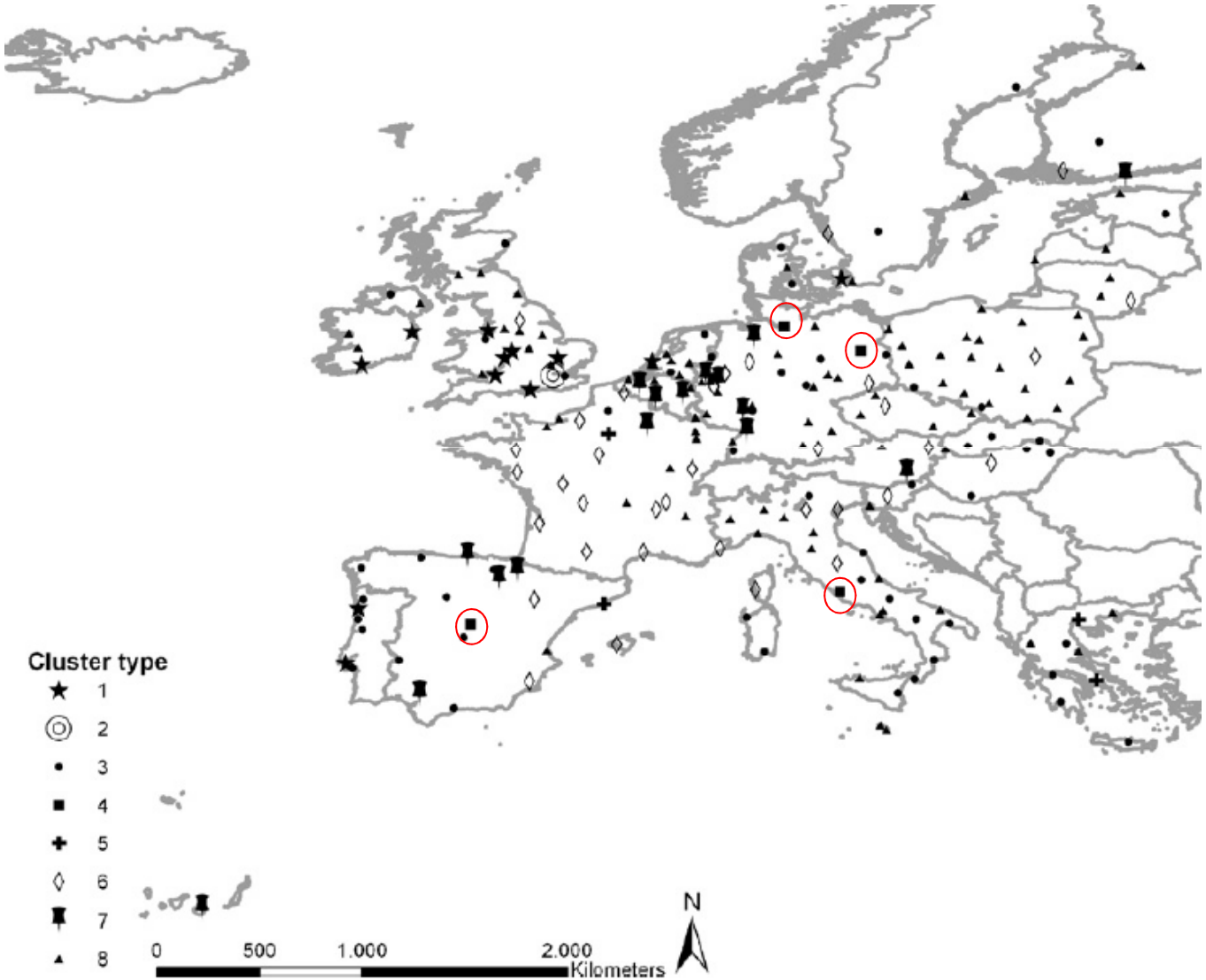
Resultados – clusters



Cluster 3

- Below average values
- Lower edge density
- Lower population density
- Lower population number
- Lower area of discontinuous urban fabric
- Small cities are scattered over European countries including Italy, Germany and Spain.

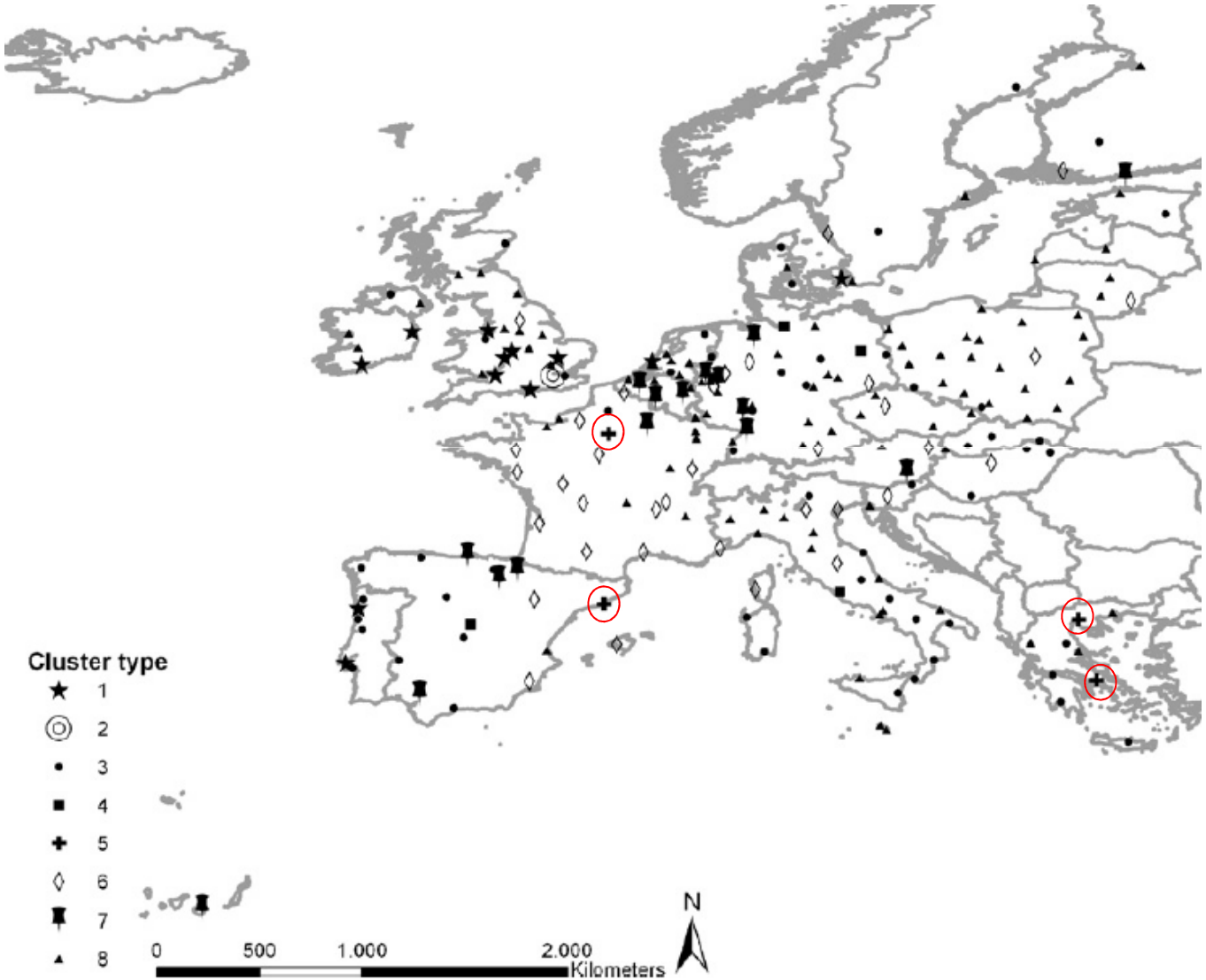
Resultados – clusters



Cluster 4

- Higher than average population number
- Higher area of discontinuous urban fabric
- High number of patches
- Scattered, low-density spatial development
- Rome, Madrid, Berlin and Hamburg

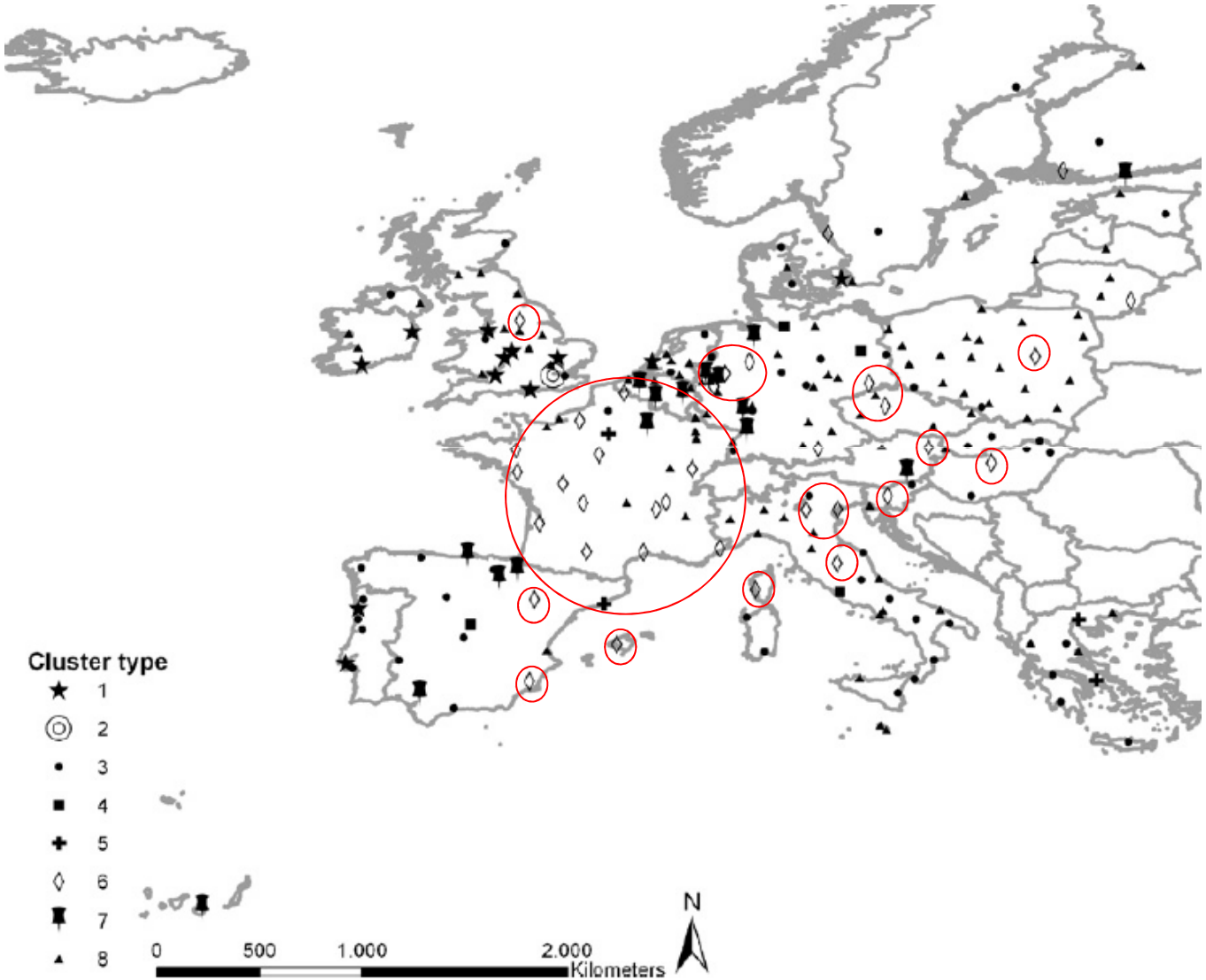
Resultados – clusters



Cluster 5

- Very high population density
- High population number
- Higher mean patch size
- Number of patches is lower than the average
- Denser and less urban area concentrated in larger sealed urban patches than cluster 4
- Athens, Thessaloniki, Paris, Barcelona

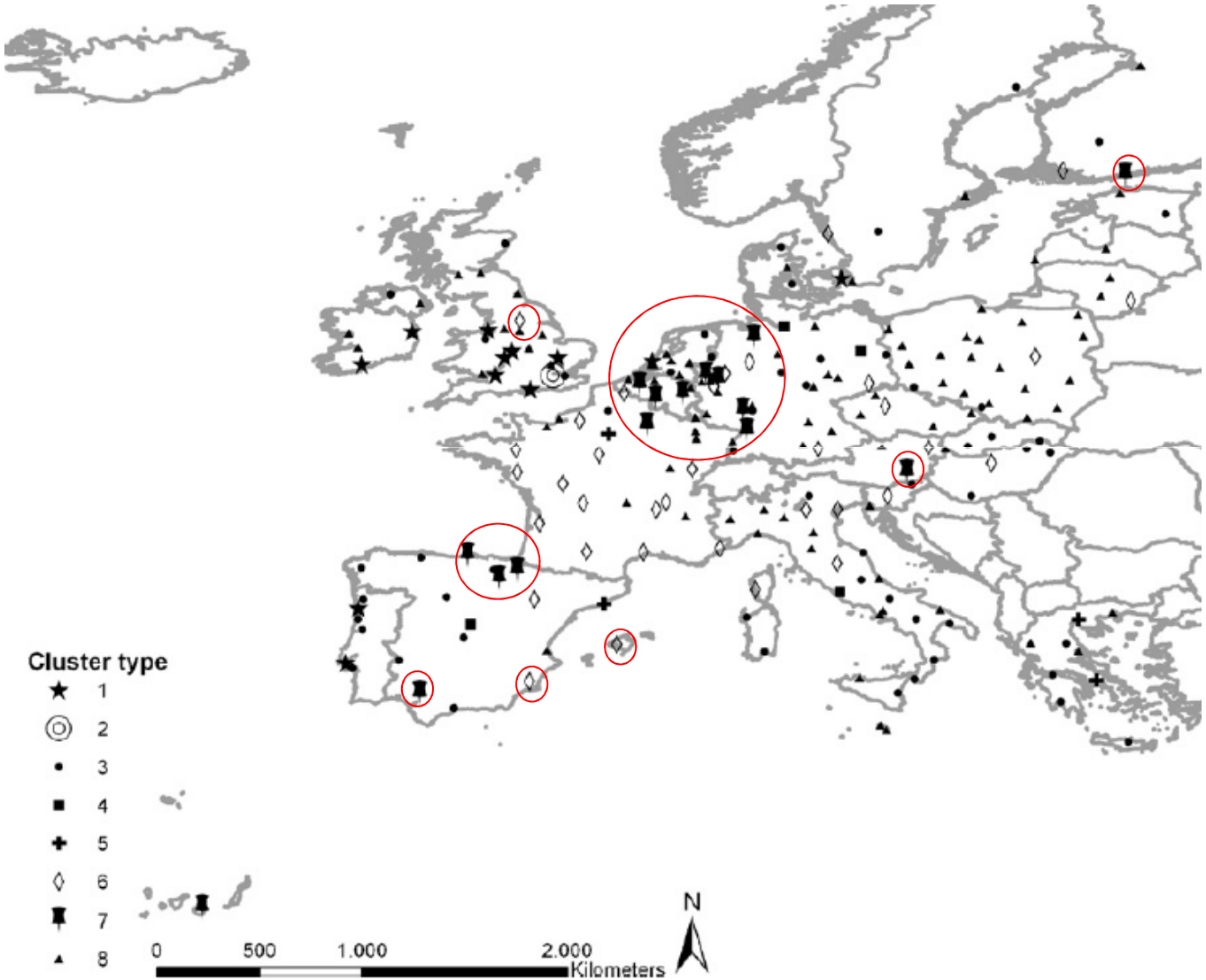
Resultados – clusters



Cluster 6

- Higher number of patches
- Lower compactness index of the largest patch
- Higher area of discontinuous urban fabric
- Smaller than cluster 4
- French cities in and Germany, Spain and Italy

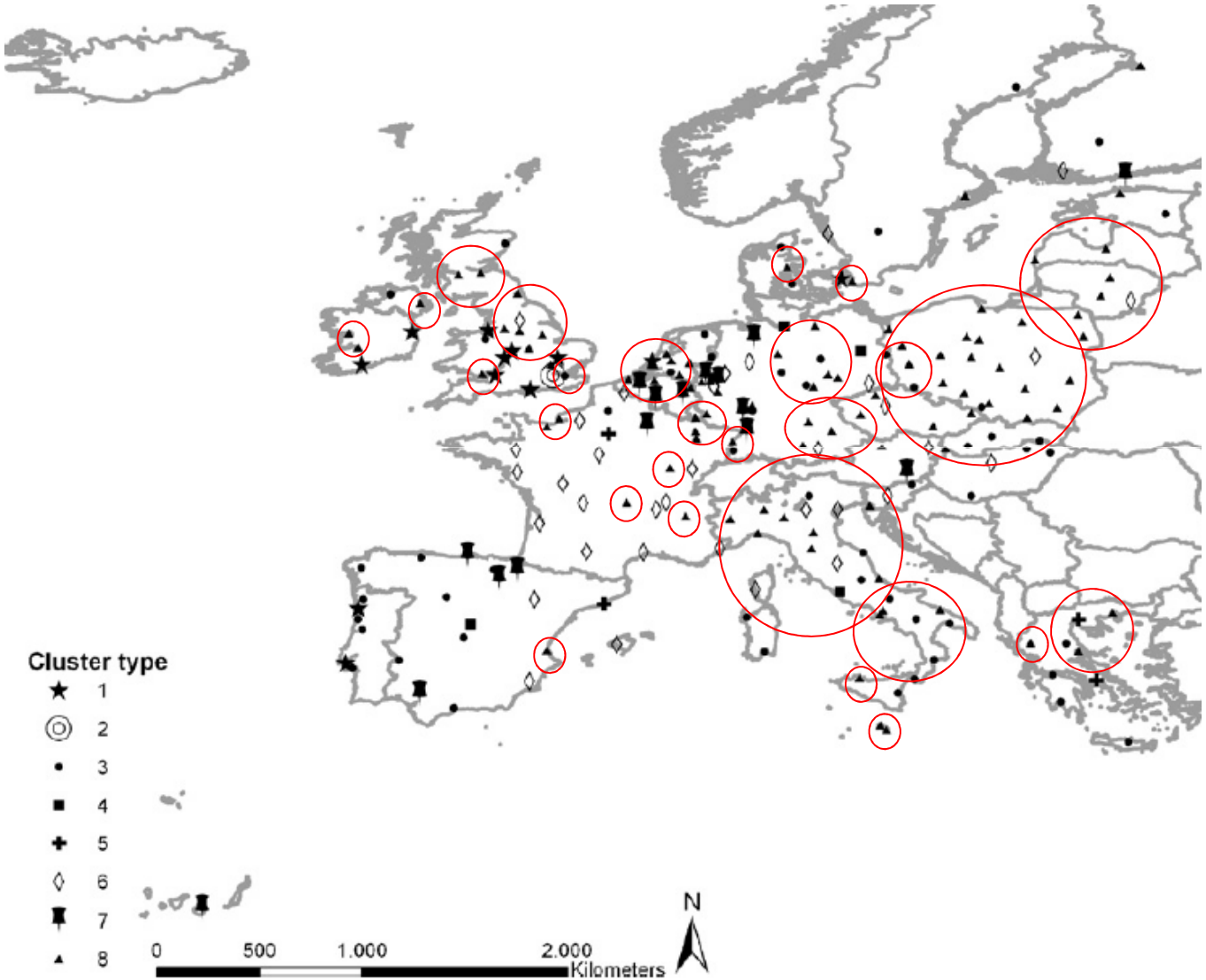
Resultados – clusters



Cluster 7

- Higher compactness index of the largest patch
- High edge density
- Regularly shaped large patch of small sealed urban patches
- Germany, Spain, and Belgium

Resultados – clusters



Cluster 8

- Higher edge density
- Lower number of patches
- Few, but ragged sealed urban patches
- Poland, Germany, Italy, France and other countries

Resultados – sumarização dos dados

One-way analysis of variance for clusters of European cities.

		Cluster 1	2	3	4	5	6	7	8
		N 12	1	56	4	4	36	16	99
	Urban form indicators								
	ANOVA F	M (SD) cluster 1	M (SD) cluster 2	M (SD) cluster 3	M (SD) cluster 4	M (SD) cluster 5	M (SD) cluster 6	M (SD) cluster 7	M (SD) cluster 8
Area discont	115.7 (7, 220), 0.000	−0.01 (0.66)	11.37*	−0.40 (0.19)	2.66 (1.79)	−0.61 (0.04)	0.53 (0.73)	−0.19 (0.42)	−0.14 (0.34)
ED	30.0 (7, 220), 0.000	0.45 (0.58)	−0.12*	−1.14 (0.62)	−0.38 (0.69)	0.37 (0.57)	−0.04 (0.76)	1.01 (1.25)	0.44 (0.69)
MPS	46.9 (7, 220), 0.000	2.93 (2.07)	2.54*	−0.37 (0.45)	0.06 (0.47)	1.90 (1.09)	−0.37 (0.39)	−0.08 (0.46)	−0.10 (0.47)
NP	73.1 (7, 220), 0.000	−0.98 (0.11)	1.64*	−0.35 (0.42)	2.85 (1.45)	−0.92 (0.19)	1.61 (0.84)	−0.33 (0.50)	−0.30 (0.50)
CILP	25.2 (7, 220), 0.000	0.11 (0.63)	−1.65*	0.17 (1.00)	0.31 (1.52)	0.76 (0.64)	−0.74 (0.57)	2.11 (0.41)	−0.18 (0.68)
Pop	123.3 (7, 220), 0.000	−0.05 (0.40)	10.62*	−0.41 (0.13)	3.52 (1.11)	1.24 (1.21)	0.30 (0.70)	−0.19 (0.27)	−0.14 (0.38)
Pop dens	132.6 (7, 220), 0.000	0.79 (0.53)	0.86*	−0.54 (0.17)	0.35 (0.54)	6.16 (0.77)	−0.31 (0.37)	0.22 (0.64)	0.01 (0.53)
	Socio-economic indicators								
	ANOVA F	M (SD) cluster 1	M (SD) cluster 2	M (SD) cluster 3	M (SD) cluster 4	M (SD) cluster 5	M (SD) cluster 6	M (SD) cluster 7	M (SD) cluster 8
GDP/capita	2.7 (7, 197), 0.012	0.43 (0.87)	1.02*	−0.30 (0.84)	0.32 (0.78)	2.02 (2.26)	0.14 (0.60)	0.27 (0.82)	−0.05 (1.15)
Prop high education	1.6 (7, 187), 0.153	0.19 (1.17)	1.30*	−0.26 (1.07)	0.15 (0.75)	0.54 (0.12)	0.32 (0.88)	0.39 (1.25)	−0.06 (0.96)
cars	0.0 (187, 5), 0.000	−0.67 (0.55)	−0.73*	0.15 (1.12)	0.65 (1.95)	−1.26*	0.35 (0.64)	0.05 (0.30)	−0.12 (1.05)
PC in hh	0.9 (5, 57), 0.471	0.14 (0.02)	§	−0.10 (1.09)	0.97 (0.93)	§	0.21 (1.21)	0.38 (0.72)	−0.19 (0.98)
www in hh	0.0 (57, 5), 0.000	0.28 (0.43)	0.98*	0.28 (1.17)	§	§	−0.19 (1.03)	−0.17 (0.97)	−0.17 (1.08)

M: mean, SD: standard deviation. See Tables 1 and 2 for abbreviations of indicators.
* Only one case available, therefore no SD.
§ No data available. ANOVA: F (degrees of freedom (df) between groups, df within groups), significance level. Means and standard deviations refer to the Z-scores of all values. Therefore, deviations from 0 indicate values higher or less than the average in the overall sample.

- The four cities in cluster 5 and to a lesser extent London (cluster 2) have a very high GDP per capita compared to the average of the sample.

Discussão dos resultados

- Data quality
- Spatially delineating cities
- Defining the minimal indicators set
- Comparing European cities
- Urban form and human welfare

Conclusões

- Comparisons among European cities should be pursued very carefully because **they are very diverse**.
- Groups of European cities with similar urban form **do not stick to national borders**.
- Future research regarding urban form of European cities **should compare different ways of delineating cities like administrative boundaries**, urbanised areas as detected by remote sensing or buffer zones around central business districts.
- The appropriateness of the minimal indicator set for world **regions other than Europe should be checked.**

Conclusões

- Policy makers not only have to keep in mind the current urban form of cities in Europe but also the **governance structures** that are applied in different cities. Comparative research regarding the influence of governance structure on urban form could inform policy makers on helpful governance structures to reach their goal of a compact city.
- **An interdisciplinary study of urban form including landscape metrics, socio-economic factors and governance structures combined with a historical analysis** would greatly enhance the understanding of emerging urban form.

Para pensar...

"In this study, **no definition of 'urban form'** as such was elaborated beforehand."

"The main aim of this study is to determine indicators for measuring urban form empirically and **not use *ex-ante* assumptions**."