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## Conference Paper

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# **Spatial patterns of land use: morphology and demography, in a dynamic evaluation of urban sprawl phenomena along the Spanish Mediterranean coast**

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**Keywords:** spatial models, urban morphology, land occupation, dispersion, density

## **ABSTRACT**

Based on theoretical concepts about urban sprawl, such as land consumption and population density, this study aims to provide a methodology for defining models of urban development and, through a temporary cut, dynamically analyze the changes that have occurred in the patterns of urban growth in the last two decades and along the Spanish Mediterranean coastline.

The paper examines the regions of Catalonia, Valencia, Murcia, Andalusia and the Balearic Islands and takes into account three temporal stages of urban development, 1990, 2000, 2006, by using database of CORINE Land Cover and INE data. We apply quantitative indices of urban morphology and density on these database, and through statistical analysis and GIS technologies, we classify types of spatial and temporal behaviours of urban models by using statistical methods. The spatial relationships between full and empty spaces, in terms of distances between urbanized polygons, and physical and functional hierarchies, make part of a semantic code which is often used to define conceptually the contemporary urban environment.

The examination of growth models finally gives us useful information concerning the assessment of sustainability characteristics and future development prospects in an area heavily pressured by human intervention.

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## 1. INTRODUCTION

Urban form is one of the main characteristics of urban areas which affect its sustainability. It has a bearing on the size of the ecological footprint of the city, degree of soil sealing, transport (length of trips and modal split), air pollution, social segregation, etc. Although there have been and still are debates on to which degree compact urban form is more sustainable than a fragmented and sprawling city (Williams 2000), there is a relatively wide consensus among planners and researchers that compactness is a desirable from the point of view of sustainable development (Newton 2000) (Kasanko et al. 2007).

Far from a typical Mediterranean model, today is practically impossible not to discuss European cities without taking into account phenomena of urban sprawl, which bring at dynamics of dispersion of artificial soil in rural areas, discontinuously but plentiful. Excessive alternating between urban and non-urban, more and more difficult to identify, currently configured natural space around cities such as residual areas between built structures. New "urban forms" are drawing new Mediterranean cities, which were dominated by the compactness of the urban fabric, while now are result of the sum of peri-urban areas, dispersed and with low density. In figure 1 it is possible to compare different topologies of modern Mediterranean cities, from a model of compactness to a urban sprawled structure.

**Figure.1** Examples of current models for the Mediterranean city in Spain



Within these structures, which we define by using conceptual forms, dominates a variety of relationships between the composing parts, such as the proximity or contiguity, distances, the similarity or diversity generated by subtracting or adding objects, and modelling the space. This urban space understood as an area with certain well-defined and dimensioned relationships, is a commonly shared idea to define a city.

The way to compose these relationships, resulting in the occupation of land, deriving from demographic and economic dynamics, generates different patterns of urban growth, which define spatial structures with different degrees of fragmentation or dispersion of urbanised areas on the territory.

There are a large number of drivers which have made urban areas less compact during the past decades. Macro-and micro economic factors, such as economic growth, rising living standards and intra-municipal competition are the underlying triggers for urban sprawl. It is also affected by transport issues and housing preferences (Kasanko et al. 2007) but certain geographical ambits, during the last decades, has also be affected by dynamics connected to the tourism.

Urban development has also been the support of industry and services, and has enabled the development of tourism and property development to take place. From the residential perspective, despite the great tensions that have occurred resulting from migration, the urban residential market has allowed for access to housing for the vast majority of the population, at least as it relates to basic housing requirements. The massive urban development of land has placed Spain in the ranking of housing production per capita in Europe, well above the needs arising from new household formation (Romano at al. 2010). Much of the urbanized land has affected the coastal areas, especially in the Mediterranean side.

## **2. OBJECTIVES**

Based on upon mentioned assumptions, and with intend of analyzing and evaluating these interesting dynamics of urban growth in specific geographical areas, we focused on the following objectives:

- Calibrate a set of indicators capable to compose an explanatory model for delineating patterns of land occupation
- Detect those areas of increasing urban pressure and the characters of urban models
- Identify the main factors, either territorial or economic, which affect urban dynamics and their effect on growth process.

The work will proposes a methodology to analyze the variation, in time and space, of patterns of land occupation based on various indicators, for the detection of regional patterns of behaviours in the urban growth process. With the results obtained, and considering the different speed of changing for each variable during around the last twenty years, we will delineate a "snapshot" survey of actual trends in urban development dynamics along the Spanish Mediterranean cost.

### 3. DATA ANALYZED AND STUDY AREA

The analysis, carried out in this paper, takes into account two main elements: the rate of population and the amount of land consumed for the urbanization, during around twenty years, and observed in the three temporal stages of 1990, 2000, and 2006. It makes possible to detect dynamically, the trend of development of the urban areas in Spain, focusing the attention on the Mediterranean area, which has been object of strong speculative phenomena in the field of constructions, during the last decades.

The database used to compute the amount of urbanized areas, is drew upon data of land classification processed by the CORINE Land Cover<sup>4</sup> project. The classes used in the analysis of urban land for this period, were those described in the first level of CORINE's artificial land, as shown in the table 1.

**Table.1** Description of the categories for artificial surfaces, like implemented in CORINE Land Cover

Level 1	Level 2	Level 3
1. Artificial Surfaces	1.1 Urban Fabric	1.1.1 Continuous Urban Fabric
		1.1.2 Discontinuous Urban Fabric
	1.2 Industrial, Commercial and Transports Units	1.2.1 Industrial and Commercial Units
		1.2.2 Road and Rail Networks
		1.2.3 Sea Ports
		1.2.4 Airports
	1.3 Mines, Dumps and Construction Sites	1.3.1 Mineral Extraction Sites
		1.3.2 Dump
		1.3.3 Construction Sites
	1.4 Artificial non-agricultural vegetated areas	1.4.1 Green Urban Areas
		1.4.2 Sport and Leisure Facilities

CORINE Land Cover provides polygons, in shapefile format, for every class type and unbundled at patch level. We merged together the classes of the level 1 in order to obtain the final class, which we will call urbanized areas (an example in figure 2), object of this investigation.

**Figure.2** An example of the urbanized area for the years 1990, 2000, and 2006

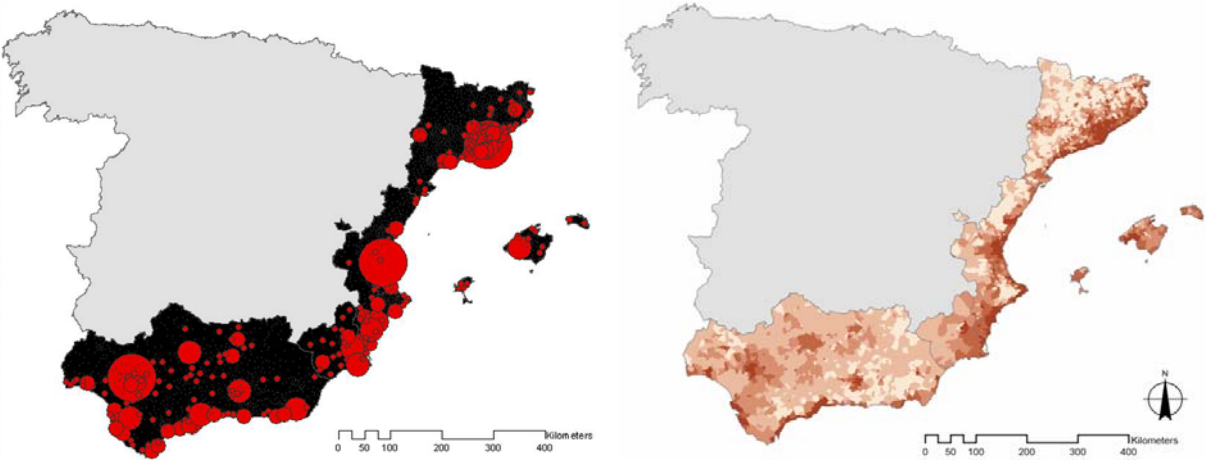


<sup>4</sup> CORINE Land Cover project is a joint initiative of the European Environment Agency and the European Commission which has affected 26 countries and includes the acquisition of land cover data at a European level, through remote sensing techniques applied at Landsat 7ETM + satellite images, and photo interpretation.

For the data relative to the population, in the years 1990, 2000, and 2006, has been used the database of the municipal register, deriving from the survey of Spanish National Statistics Institute (INE) for the years 1991 and 2001.

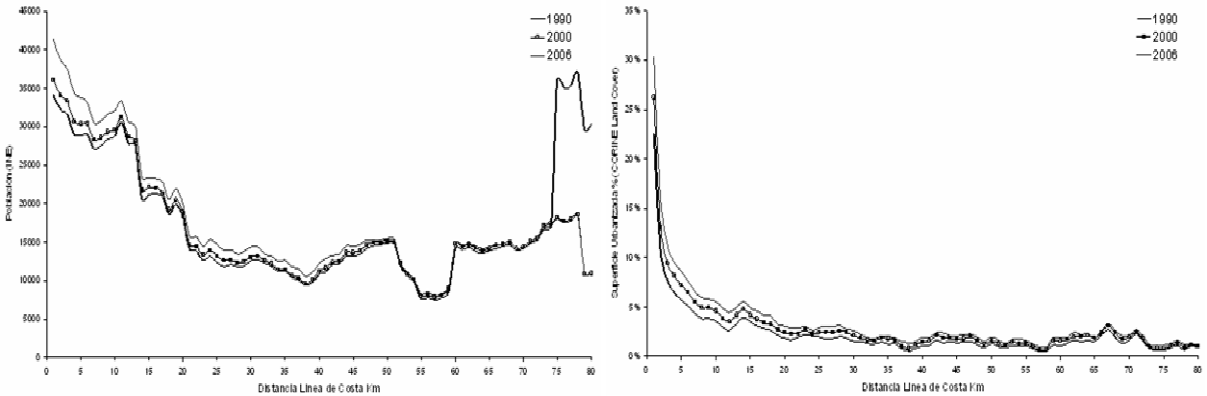
In order to delimitate the ambit of the area under investigation, it has been decided to analyse the five autonomous communities, based on the Spanish administrative division, which border the Mediterranean side. Figure 3 show the spatial distribution of population and rate of urbanized area along the ambit upon mentioned.

**Figure.3** Spatial distribution of population and percentage of urbanized area for the five autonomous communities along the Mediterranean cost



It also was important to intend the behaviour of such indicators, take into account the effect of the first coastal line upon the inside territory. In figure 4 it is shown the trend of population rate and urbanized area, for the three temporal stages 1990, 2000, and 2006, up to 80 kilometres from the coast line and measured for each kilometre.

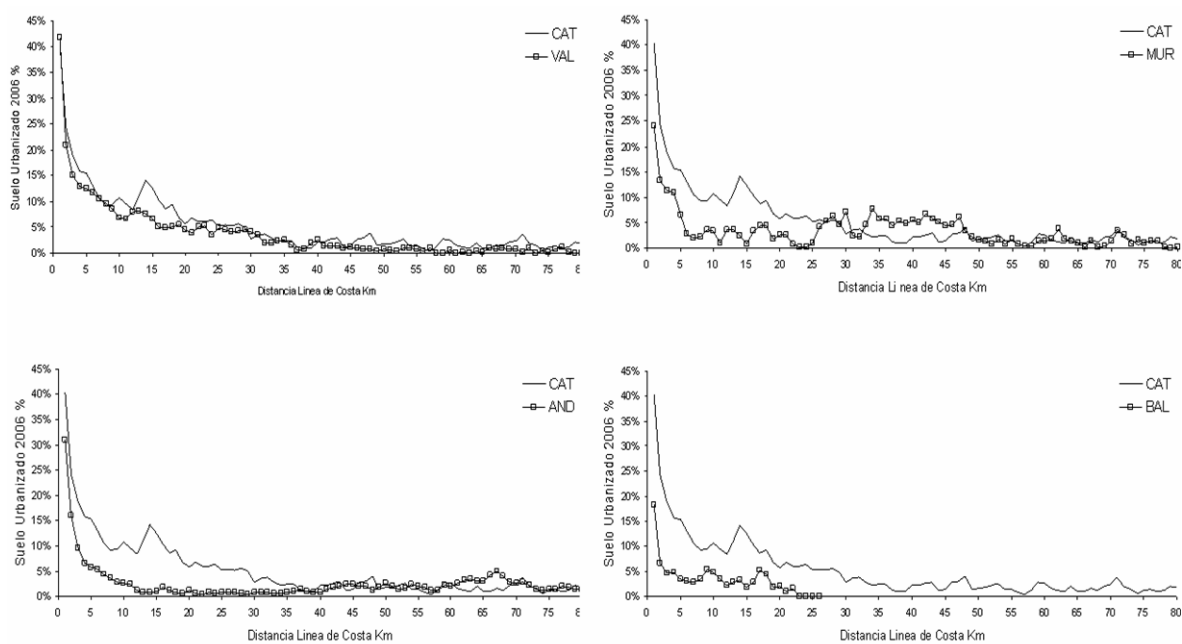
**Figure.4** Trend of population rate and urbanized area in the first 80 km from the coast line in 1990, 2000, 2006



The graphics show clearly that along the first 10 km from the coast line, both the rate of population and the amount of urbanized areas is reaching a very high level. In addition the speed, in the rate of urbanization and population, is being higher towards the coast line mostly between 2000 and 2006.

Figure 5 shows the percentage of urbanized land at 2006, for Catalonia compared with the other autonomous communities, along the first 80 km from the coast line.

**Figure.5** The rate of urbanized area for the 2006 and in the first 80 kilometres from the coast line, for Cataluña in comparison with Valencia, Murcia, Andalucía, and Baleares



It is clear that there is a strong influence of the coastal zone on the dynamics of urban development, that we call “coast effect”, and which brought us to analyze with more details what is occurring, in the last decades, in this particular geographic context.

#### 4. METHODOLOGY

The analysis about urban models of territorial occupation is carried out by applying quantitative indices concerning form and structure of the profile of urban patches, and the intensity of urbanization in terms of density of population and occupied area. The indices, shown in the table 2, have been computed depending on the administrative boundaries of municipalities, and for the entire national territory of Spain.

**Table.2** Set of indices selected

INDICE	FORMULA	DETAILS
<b>Land Occupation</b>	$O_s = \frac{S_{up} Urb}{S_{up} Ter} * 100$	The ratio between urbanized area ( $S_{up} Urb$ ) and the area of municipality ( $S_{up} Ter$ )
<b>Gross Density</b>	$D_B = \frac{Pob}{S_{up} Ter}$	The ratio between population ( $Pob$ ) and the area of municipality ( $S_{up} Ter$ )
<b>Net Density</b>	$D_N = \frac{Pob}{S_{up} Urb}$	The ratio between population ( $Pob$ ) and the urbanized area ( $S_{up} Urb$ ) for each municipality
<b>Shannon Diversity<sup>5</sup></b>	$SHDI = -1 \sum_{i=1}^n [P_i (\ln P_i)]$	Equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion (McGarigal et al. 2002). $P_i$ is the ratio between area of a polygon $a_i$ , and the total area of the urban landscape $A$ , under investigation.
<b>Shannon Evenness<sup>6</sup></b>	$SHEI = \frac{-\sum_{i=1}^n [P_i (\ln P_i)]}{\ln m}$	Equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion, divided by the logarithm of the number of patch types (McGarigal et al. 2002)
<b>Degree of Landscape Division<sup>7</sup></b>	$D = 1 - \sum_{i=1}^n \left( \frac{a_i}{A_t} \right)^2$	The quadrate of the ratio between the area of a polygon $a_i$ , and the total area of the urban landscape $A$ , under investigation.
<b>Standard Distance<sup>8</sup></b>	$SD_w = \sqrt{\left( \frac{\sum_{i=1}^n a_i (x_i - \bar{X})^2}{A_t} \right) + \left( \frac{\sum_{i=1}^n a_i (y_i - \bar{Y})^2}{A_t} \right)}$	Measures the degree to which features are concentrated or dispersed around the points (or feature centroids) in an input feature class.
<b>Gini Relative Index of Concentration</b>	$C_G = \frac{2}{(n-1)} \sum_{i=0}^n (P_i - Q_i)$	$n$ is the number of patches in an ambit, $P_i$ is the cumulative percentage of patches on the total number of patches; $Q_i$ is the cumulative percentage of area of each patch upon the total area.
<b>Area Weighted Mean Shape Index<sup>9</sup></b>	$AWMSI = \sum_{i=1}^n \left( \frac{P_i}{2\sqrt{\pi a_i}} \cdot a_i \right) \frac{1}{A_i}$	Equals the sum of each patch's perimeter $p_i$ , divided by the square root of patch area $a_i$ and adjusted for circular standard. It's weighted by patch area so larger patches will weigh more than smaller ones.
<b>Area Weighted Mean Patch Fractal Dimension<sup>10</sup></b>	$AWMPFD = \sum_{i=1}^n \left[ \frac{2 \ln(0,25 \cdot p_i)}{\ln a_i} \cdot a_i \right] \frac{1}{A_i}$	Equals 2 times the logarithm of patch perimeter $p_i$ (m) divided by the logarithm of patch area $a_i$ (m <sup>2</sup> ). The result is weighted by the dimension of each patch $a_i$ , upon the total area $A$ .

<sup>5</sup> Shannon's diversity index is a popular measure of diversity, applied here to the urban landscapes. It equals zero when the landscape contains only 1 patch (i.e., no diversity) (McGarigal et al. 2002).

<sup>6</sup> Shannon's evenness index is expressed such that an even distribution of area among patch types results in maximum evenness. As such, evenness is the complement of dominance (McGarigal et al. 2002).

<sup>7</sup> The degree of landscape division is defined as the probability that two randomly chosen places in the landscape under investigation are not situated in the same undissected area (Jaeger 2000)

<sup>8</sup> Like implemented in ESRI ArcGIS Desktop

<sup>9</sup> Like implemented in Patch Analyst 0.9.5

<sup>10</sup> Like implemented in Patch Analyst 0.9.5



The use of such indicators can achieve synthetic descriptive measures of spatial distributions of specific phenomena, and in a specific geographical zone, to provide comparative analysis between urban growth models. We aim to quantify the complexity of urban areas by considering patterns of discontinuity in the tissue and the relationships between polygons that comprise the profile of urban shapes, and the shape itself, together with the assessment of growth of the urbanized area and the rate of population. In particular the analysis of the dispersion of tissue based on observation of the frequency of artificial soil units (built area on empty space) and in accordance with the size of the units and the distances between them, provides a useful tool to define patterns of "structural" urban growth.

After applying an exploratory statistical analysis on the indices, to find out strong correlations, it was decided to employ the method of principal components of the factorial analysis to avoid collinearity, and in order to obtain synthetic indicators taking into account the main characteristics of the initial indices. We worked on most than 3.500 municipalities observed around the entire territory of Spain<sup>11</sup>. The result of the total variance explained by the factorial analysis is shown in the table 3.

**Table.3** Components and total variance explained

Component	Total Variance Explained								
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	% of Variance	Total	% of Variance	Cumulative %
1	4,420	44,201	44,201	4,420	44,201	44,201	4,315	43,152	43,152
2	2,015	20,150	64,351	2,015	20,150	64,351	1,824	18,235	61,387
3	1,607	16,066	80,418	1,607	16,066	80,418	1,774	17,737	79,124
4	,916	9,163	89,581	,916	9,163	89,581	1,046	10,457	89,581

Extraction Method: Principal Component Analysis.

We obtained four components by using varimax rotation method, which achieve to explain around the 90% of the model, and representing the different dimensions of the phenomena under investigation. The communalities table denotes a high percentage of extraction for the components, and the KMO test computes a value of 0.688, which indicates the goodness of the extracted main factors.

<sup>11</sup> Actually the national territory of Spain has more than 8,000 municipalities, but due to administrative boundary changes, during the last twenty years, and also a lack of information on population data and limits in detecting urban areas throughout the project CORINE land cover, we could only work on a limited database.

Table 4 shows the structure of the main factors extracted from the original variables. The interpretation of the factors makes it possible to name the new synthetic indices as follow: *magnitude*, *density*, *dispersion*, *complexity*.

**Table.4** Result of factorial analysis and interpretation of components

	Rotated Component Matrix <sup>a</sup>			
	Component			
	1	2	3	4
	<b>Dispersion</b>	<b>Complexity</b>	<b>Magnitude</b>	<b>Density</b>
O <sub>S</sub>	,072	,088	,942	-,077
D <sub>B</sub>	-,030	-,012	,907	,237
D <sub>N</sub>	-,103	,085	,119	,975
SD <sub>w</sub>	,816	,096	-,015	-,001
SHEI	,962	,036	,024	-,051
SHDI	,937	,101	,066	-,074
C <sub>G</sub>	-,923	,012	,029	,035
D	,980	,069	,044	-,070
AWMSI	,128	,941	,184	-,033
AWMPFD	,042	,948	-,093	,129

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

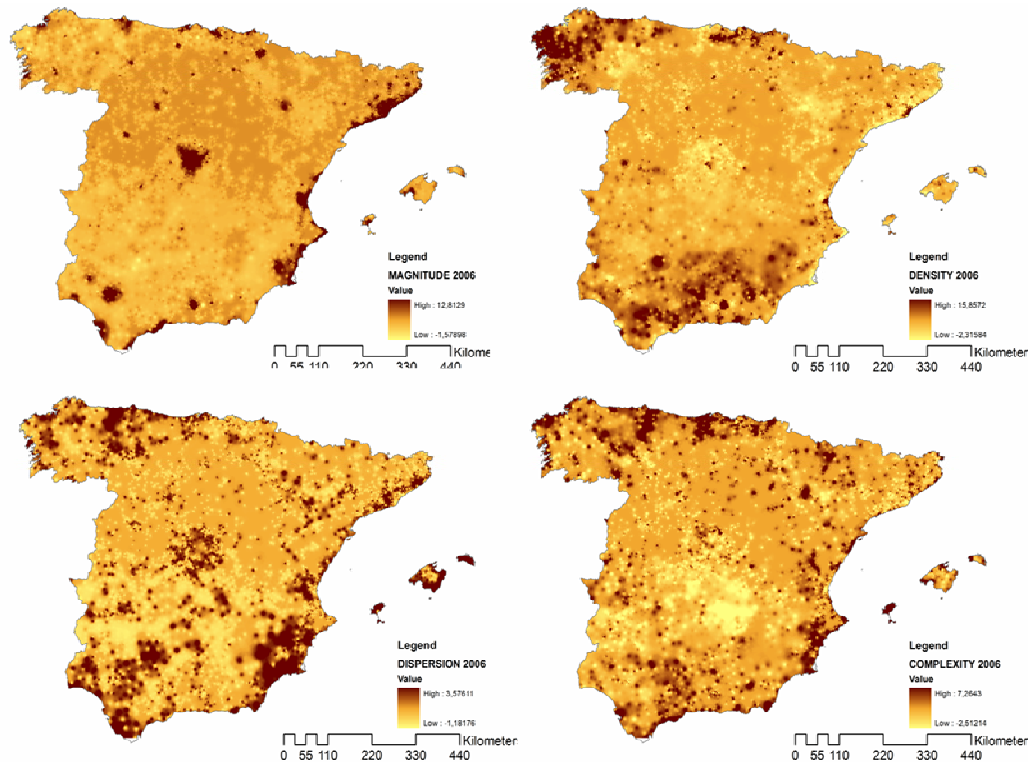
a. Rotation converged in 4 iterations.

- *Dispersion*<sup>12</sup>: positive values of this factor are associated to high values of fragmentation and dispersion (evenness, diversity, standard distance, and landscape division). While a negative value is associated with high value of the Gini index of concentration.
- *Complexity*: positive values of this factor are associated to high values of convolution of the profile of urban polygons, i.e. fractal and shape index.
- *Magnitude*: positive values of this factor are associated to high values of land occupation and gross density. This indicator describes the intensity of human pressure on the territory.
- *Density*: positive values of this factor are associated to high values of net density, which describes the capacities of urban settlements to keep more population, within less sprawled urban areas.

<sup>12</sup> The dispersion index is a synthetic index, derived from the *Shannon* indices refers to the degree of fragmentation of an urban structure, the *Gini* index that calculates the level of concentration of urban areas in one or more polygons, and the *standard distance* that measures the distances between urban polygons weighted by the size of the polygon itself in terms of urban area.

By using a G.I.S. platform we provide, as shown in figure 7, the spatial behaviour of the synthetic indices over the entire Spanish territory.

**Figure.7** Spatial distribution for the values of the synthetic indices



## 5. RESULTS AND DISCUSSION

This kind of research on evolutionary models may facilitate the identification of types of growth which are away from the "typical" Mediterranean city, compact and dense. In particular the analysis of the dispersion of urban tissue, based on observation of the frequency of artificial soil units (built-up area/empty space) and according to the size of the units, to define structural patterns of urban growth.

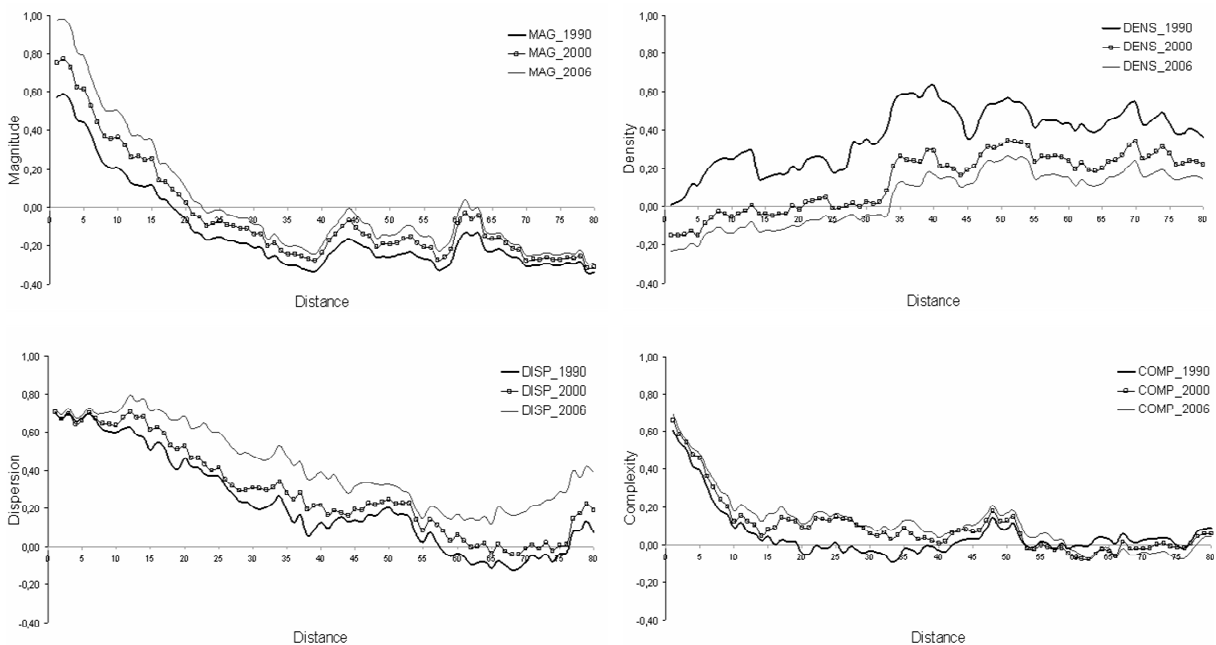
The key that we used for the interpretation of results is based on conceptual models of urban settlements (figure 8), which consists of distinct phases of development, ranging from the formation of a compact nucleus and little extended on the territory, until a metropolis, little fragmented but continuous and extended on the territory. Between these two models, the urban fabric passes through various stages of growth, by changing the values of dispersal and the degree of compactness in a very dynamically way, mostly due to demographic and economic dynamics, but also related to the topography of land and then due to particular geographical position.

**Figure.8** Possible conceptual models of urban settlements



The evaluation of the synthetic indices is used to detect the hypothesized models, along the area under investigation. Firstly, to plot the trend of the indices along the Mediterranean coast, between 1990 and 2006, it has been calculated the average of variables at each kilometre of land parallel to the coastal line, and up to 80 km (figure 6).

**Figure.6** Magnitude, density, dispersion, complexity along the Mediterranean coast, in the 1990, 2000, and 2006

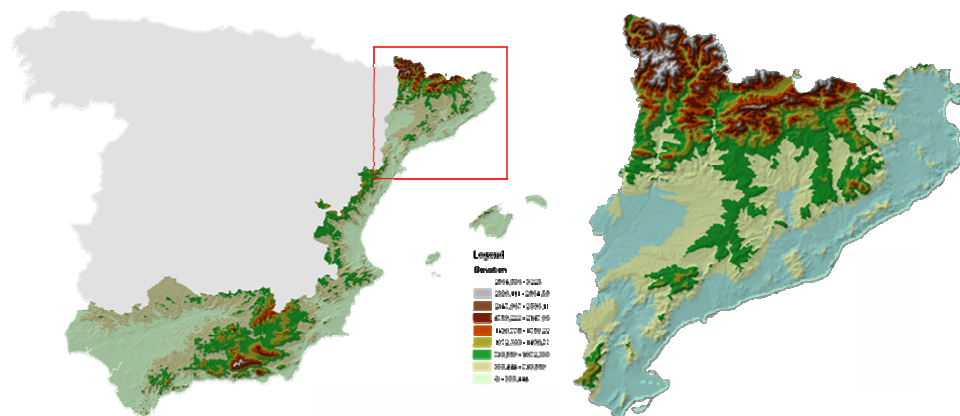


The low relation between the increase of magnitude and the density, mostly along the first 20 kilometres from the coast line, indicates different speeds in population growth with respect to the urban land rate increasing, while dispersion and complexity show strong connections with the increase rate of land occupation, and low levels of urban density towards the coast. By analysing the level of dispersion and complexity, together with magnitude and density, it is clearly observed in some areas a cyclical process of an initial phase of dispersion, and a second phase of compaction. In fact the drop of the index depends on the growth of contiguous urban polygons, which tend to fill the gaps that had been generated in the years of great expansion and economic boom characterized for a "jumping-stains" type of urbanization. The increase in the rate of urbanization over time, has generated a decreasing in

the degree of fragmentation in large cities, i.e. in those areas more "mature" from the point of view of metropolitan development. The medium dimension cities, which are still experiencing its urban expansion, and mostly those cities which are around a big metropolis, tend rather to maintain a high level of dispersion or even increase it in some cases.

Away from strong “urban catalysts” such as the coastline, in the area under our investigation, or in general from big metropolises, it is possible to detect the variation of the indicators also depending on topological characters of the territory. We intend to show, by using a Digital Elevation Model (DEM) at a resolution of 80m (figure 9), that as we mentioned before it is possible to find three type of effect which are affecting the process of urban development along the Mediterranean coast. We refer to a “coast effect”, a “metropolis effect”, and a “mountain effect”.

**Figure.9** Digital Elevation Model (DEM) of the Spanish Mediterranean coast, zoomed on Catalonia



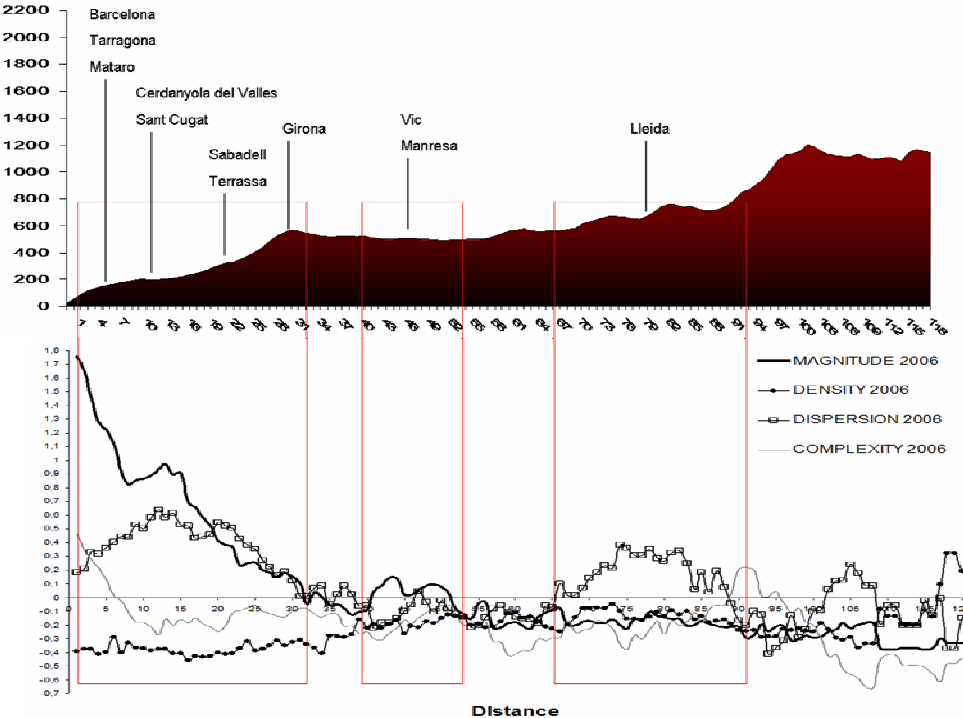
If we take a look at the DEM (figure 9) and the spatial distribution of the indicators (figure 7) it will be clear that, even in really flat areas, such as in the case of Andalusia and Murcia, but also for the ring around Barcelona (in Catalonia), the level of dispersion is being really high. The magnitude is being found high mostly for the big cities, such as Barcelona, Sevilla or the city of Murcia, but in Barcelona we can also find high values of urban density<sup>13</sup>. The values of complexity, instead, are being high mostly along the coast line of Andalusia and Murcia.

In order to better show the trend of the variables and the possibly relations with the topology of the territory, we have realized a profile of the heights of terrain on the level of

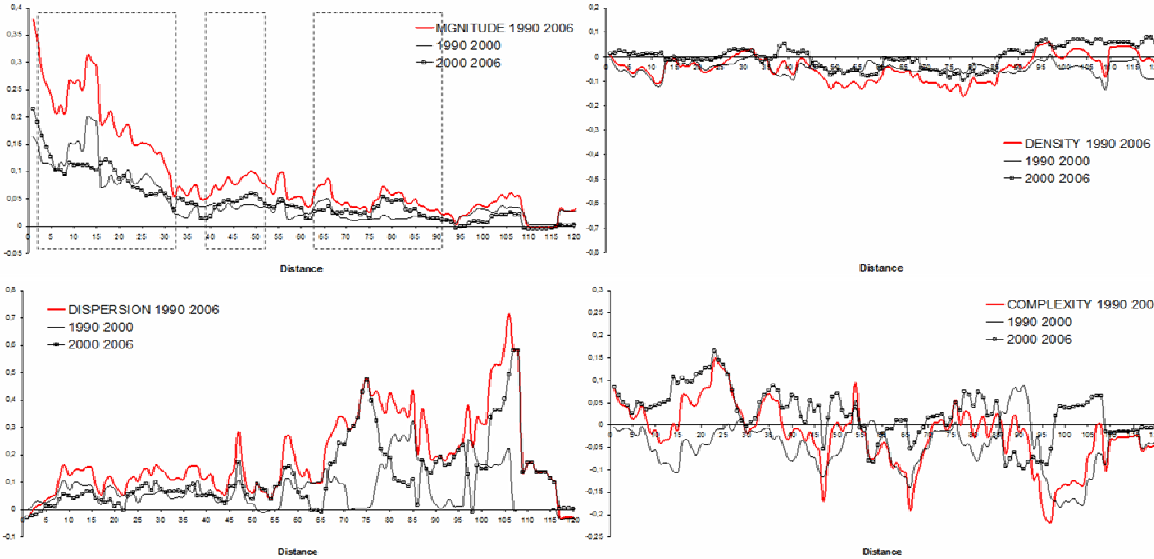
<sup>13</sup> In the city of Madrid it is possible to observe that the behaviour of the indicators being similar to Barcelona, with high level of urban density and magnitude, while low levels of dispersion, which is being high in the ring around the capital, and low complexity.

sea, based on the DEM, and for the first 120 kilometres from the coast line. It also was put the accent on the speed of changing of the variables during the last decades, by analyzing the final rate of change, from 1990 to 2006, and the changes from 1990 to 2000, and from 2000 to 2006. Here are two examples for the case of Catalonia (figure 10-11) and the case of Andalusia (figure 12-13).

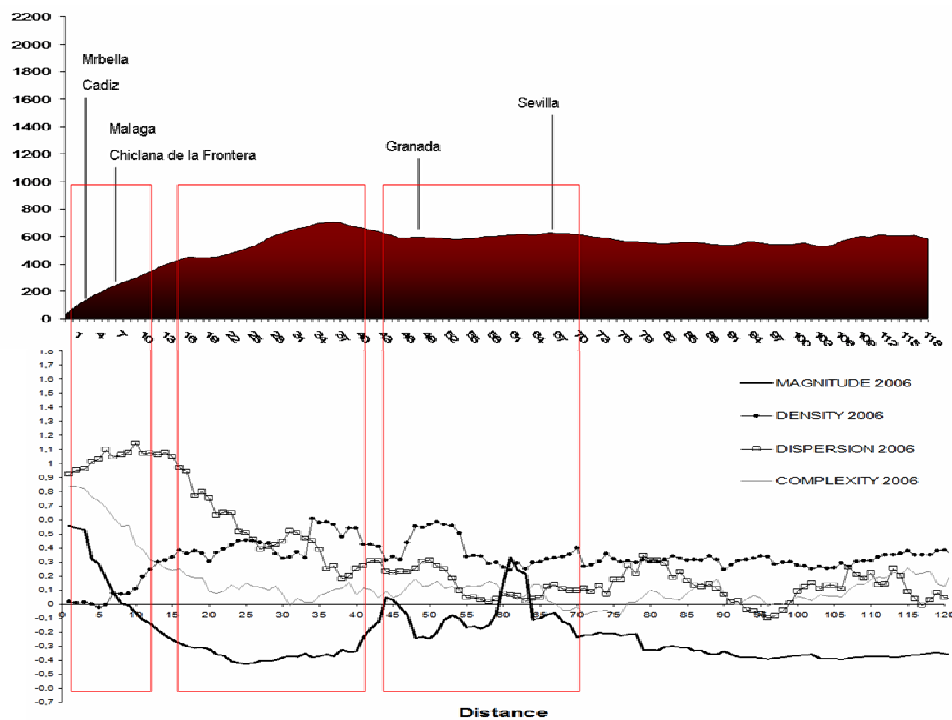
**Figure.10** Relation between indices value, at 2006, and the territory: the case of *Cataluña*



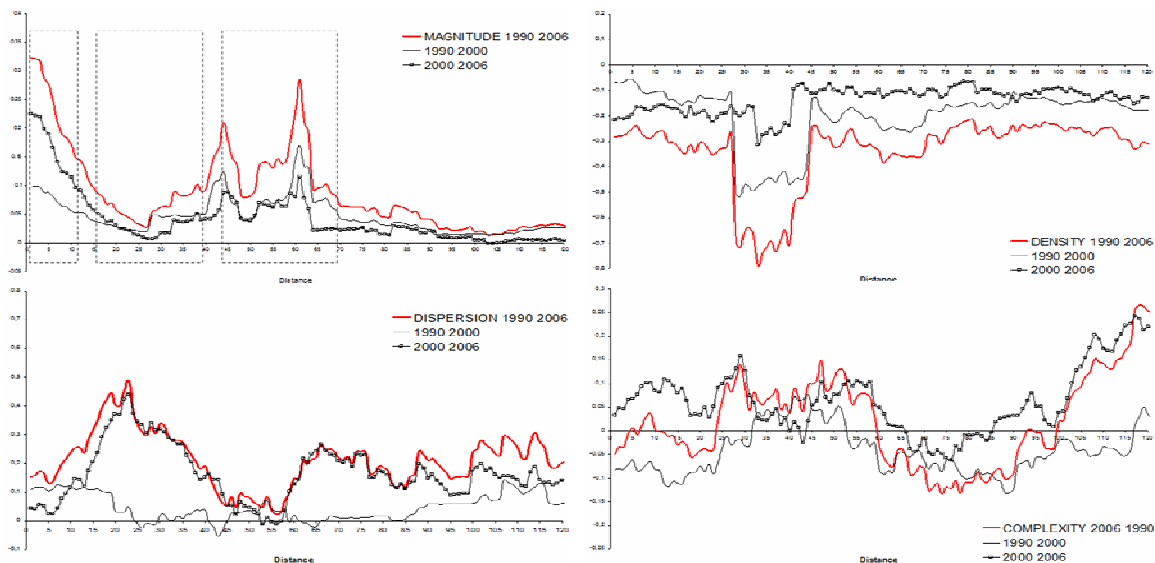
**Figure.11** Speed rate of change for the indicators in *Cataluña*, from 1990 to 2006 and detailed for two steps from 1990 to 2000, and from 2000 to 2006



**Figure.12** Relation between indices value, at 2006, and the territory: the case of *Andalucia*



**Figure.13** Speed rate of change for the indicators in *Andalucia*, from 1990 to 2006 and detailed for two steps from 1990 to 2000, and from 2000 to 2006



Reading of the indicators, together with the topological characteristics of the territory, can be really helpful for urban planners, in order to understand part of the factors which are concurring to generate phenomena of urban sprawl. The charts show different patterns of urban structures based on the different combinations of the indices. In Catalonia, for example, the models produced by *Sant Cugat*, *Cerdanyola*, *Sabadell*, and *Terrassa*, are suffering a high

level of dispersion, probably because they are covering a spread area, still in the phase of increasing metropolisation, while *Girona*, even in a phase of expansion, is quite an isolated case along that axis of distance, it means that it is not in a metropolitan system. The first lines of coast are preserving moderate levels of dispersion, due to big cities such as *Barcelona* or *Tarragona*, but the entire coastal landscape is suffering anyway a reduction of density and increasing magnitude, mostly related to phenomena related to tourism. High levels of dispersion and low in magnitude and density along the lines of *Lleida* could be due to topological aspects. Even the speed of change for the indices is supporting the hypothesis of different urban structures, related to different dynamics of growth, on the territory.

Similar considerations can be carried out by observing the case of Andalusia. Here is clear the differences between the coast effect and the metropolis effect, being *Sevilla*, but also *Granada*, far from the coast line. While, approximately between the kilometre 20<sup>th</sup> and the 40<sup>th</sup> it would be reasonable underline topological aspects which are affecting the trend of the indicators.

## 6. CONCLUSIONS

We consider important to underline few limitations of this investigation, mostly concerning the database. The first problems were connected to the data of population and the administrative boundaries. In fact we found out, on one hand, lot of lack in the data base concerning the population, on the other hand, between the year 1990 and the 2006 we noticed a consistent number of municipalities which changed its administrative limits, sometimes appearing or disappearing. These issues were a limit for in the number of municipalities used in the statistical analysis. In fact we passed from around 8000 cases to around 3500; even if we considered however reliable the analysis based on this amount of observations. Another limitation is due to the considerable generalization, made by CORINE Land Cover, on the polygons of the classification, which makes lot of limitations while calculating the characters of urban forms and urban structures; in fact a morphological analysis would require a well detailed database. Anyway, even with these limitations, we considered satisfactory and coherent the outcomes of the experiment, based on our empirical knowledge of the area object of the analysis. Of course this process could be applied on more detailed data which will give improved results.



The best goals of the investigation were mostly to propose a methodology for analyzing urban dynamics of growth, by considering the main characteristics of urban patterns, such as the rate of urbanized areas but in relation to the amount of populations, and the forms of a city, which refers about the quality of the way to develop. Based on these characteristics we built a model of analysis applied to three temporal stages, to detect urban patterns in which the rate of land consumption is higher than the rate of population growth, defined as low density growth models, which is occupying more and more the rural areas, by "jumping", separating, splitting and leaving holes of land that no longer can be classified either as urban or as rural. This kind of discontinuous fabric, being the most dynamic urban structure, often tends to modify a greater amount of territory, and land uses related to dispersed residential expansion, and mostly linked to infrastructure and new suburban centres. In recent decades, these types of urban fabric, in the costal areas mostly depending on tourism and other economic factors, are those which have grown faster, consuming far more land in agricultural areas, and generating different types of fragmentation patterns of land use. These kinds of phenomena are best known like *urban Sprawl*. The analysis and quantification of *Sprawl* of the urban system can provides a useful tool for visualizing future projections of growth patterns and underline those areas in which natural resources are threatened by this kind of growths. In this investigation we find out an estimation of sprawl by evaluating together the indicators of dispersion and complexity, with urban density and magnitude.

The most relevant result of the application of this methodology was to validate the thesis that in almost 20 years of urbanism in Spain, the expansion of artificial land has generally been higher than the population growth rate, meaning that the net density has been reduced over time, and demonstrating that the increase in the rate of building has not been the product of a real demand, nor of proper planning. The investigation also showed as the model of land occupation has been changing over time, from a denser and compact model produced of the direct relationship between the percentage of urban land and population growth rate, to a centrifugal model of occupation that tends to spread on the territory. This mechanism has pushed up the rate of spread of urban land, but has fallen in large cities the degree of dispersion, which would be interesting to assess to what extent this indicator will be really negative, being strictly connected with the percentage of urban land and therefore with the population density rate. In fact though in specific territories, a high value of dispersion indicates a type of growth mostly scattered on the territory, which often happen along costal zones; in many cities, mainly in metropolis, current trends in urban planning pushed by sustainability issues, are aiming to "fill" areas within the city itself.

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