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ABSTRACT *This article summarizes the protocol applied to analyse the spatial consequences of diverse regional plans included in the General Spatial Planning of Catalonia (GSPC) municipalities since 1985. The main aims of the GSPC were to achieve a more balanced distribution of population, avoiding Barcelona metropolitan region congestion, coastal overcrowding and mountain areas depopulation, and to improve mobility infrastructures and social welfare. The methodology used was based on factor analysis that reduced 30 socioeconomic and geographic variables provided by different sources into a smaller number of common factors. Afterwards a non-hierarchical clustering was employed to simplify the analysis of dynamics. The six first common factors retained in the model explained the 82.6% of total variance. After labelling them, six clusters were mapped to describe the most important dynamics: urban sprawl, urbanalization, depopulation, reterritorialization and coastalization. Finally, some socio-environmental consequences of such dynamics are discussed.*

Introduction

In 1994, the European Union (EU) created the Committee of the Regions to represent European regions as the layer of EU government administration directly below the nation-state level. The main reasons for establishing this administrative level were the historic and cultural claims for autonomy and the political and economic situation in many EU regions. Therefore, the idea of the "Europe of regions" has become very significant (Paasi, 2009). Examples of such regions are Toscana in Italy, Galicia in Spain, Languedoc-Roussillon in France and Wales in the UK (Le Galès & Lequesne, 1998; Precedo, 2000; Loughlin, 2001; Keating, 2006; Lloyd & Peel, 2008).

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As Halkier *et al.* (2012) assert, the regional scale has historically been considered crucial in the development of a more competitive economy in Europe from a policy perspective (p. 1760). In this sense, diverse works have analysed different issues from European regions such as innovation systems, demography, health, agriculture or environment (Tödtling & Kauffmann, 1999; Máiz & Losada, 2000; Puga, 2002; Le Gallo & Ertur, 2003; Trouvé & Berriet-Solliec, 2010). For example, Del Campo *et al.* (2008) proposed a classification of European regions according to socioeconomic indicators, including demography, economy, employment and education. Soares *et al.* (2003) used similar indicators to classify regional disparities in Portugal whereas in the case of Taylor & Bradley (1997) or in Aragón *et al.* (2003) the objective was to analyse regional unemployment disparities in Germany, Italy and the UK or to explain the regional unemployment pattern in the Midi-Pyrenees region, respectively.

In the context of different European political systems and administrative structures, it is not surprising that competencies in planning differ as well. In general, three administrative tiers are distinguished in spatial planning: the national (state), regional and local (or metropolitan). Germany, as a federalist example, is a clear case where these three levels are well established (Keenleyside *et al.*, 2009). The national government defines the principles of territorial planning or overall concepts and the legal framework (the Federal Regional Planning Act) whereas the concrete planning implementation is responsibility of Federal States (Mertins & Paal, 2009). Following regional planning policy guidelines, each of the 16 Federal States (Länder) prepares its Regional Development Plan (RDP) that will be adopted for the whole territory of a Federal State, taking into account land use patterns, free space and the main alignments of infrastructure. The Länder legislation divides its territory into planning regions, in each of which regional planning associations draw up regional plan. Each municipality then produces its land development plan, which comprises information about land use, and its legally binding land use plan, which applies to only parts of the municipality. Another example, with some differences, is provided by Sweden: its planning system is based on a decentralized dialogue among the local, regional and national levels. The national level gives advisory guidelines whereas the regional plans are optional and not binding, allowing municipalities to coordinate their planning over larger areas. Municipal councils can create master plans, detailed plans and area regulations.

The importance of regional planning, the objective of this research, is emphasized by diverse institutions. For example, the European Commission (1997) establishes that regional planning attempts to shape development patterns within a region, usually through a strategy that links physical change with economic and social policy. For the United Nations Economic Commission for Europe (United Nations, 2008) the main task of regional spatial planning is the preparation and coordination of a regional spatial strategy, with a temporal horizon between 15 and 20 years, for the overall development of the region in cooperation with regional and local stakeholders. This process includes providing local authorities with information on regional priorities, including the designation of protected areas, the planning of infrastructural improvements and the conduct of environmental assessment.

In the case of Spain, the 1978 Constitution Act introduced a new territorial organization of the state to include autonomous communities as a new political level, above the existing provinces (Zoido, 1995–1996). An autonomous community may be a single province with a historical identity or status, or two or more adjacent provinces with common historical, cultural and economical characteristics. In total, 17 autonomous communities were identified, three of which have their own distinctive language, history, culture and tradition: the Basque Country, Galicia and Catalonia (Polet & Nomden, 1997). Each of the 17 autonomous communities has its own regional government; in Catalonia, our study area, this is the Generalitat. Led by a moderate nationalist coalition when it was first established, the Generalitat has long sought to separate itself as much as possible from the Spanish administrative network (Keating, 2001). Beginning in 1980, the Generalitat developed a territorial plan, the General Spatial Planning of Catalonia (GSPC), approved in 1995, with the general objectives of redefining the functional Barcelona metropolitan area and addressing decongestion and territorial equilibration as well. Nearly 20 years later, the GSPC needs to be evaluated.

Although some researchers have studied specific regional planning facets, using a variety of methods and strategies, very few empirical studies have linked planning and spatial dynamics. Scattoni and Falco (2012) analysed the planning activity of the Tuscany (Italy) region, historically characterized by long negotiations in which municipalities tended to over-size the development areas in agreements with local developers and the region to limit them, trying to protect the environment. The authors examined the length of time needed by municipalities, after a reform of regional planning in 1995, to approve their planning documents, and conclude that the approval period required was no shorter than the traditional process. On the other hand, the work of Koschatzky *et al.* (2000) analysed the spatial distribution process of fast-growing industries in 12 planning regions belonged to the Baden-Württemberg region (comparing the results with Israel). They discuss terms such as industrial agglomeration, core regions, diffusions and decentralization processes in order to delve into the reduction of regional disparities. Another relevant example is the research of Salvati *et al.* (2012) that analyses land use changes from 1960 to 2000, extracted from land cover maps, of 122 municipalities included in the prefecture of Rome. According to their results, the main detected process was the emergence of dispersed urban expansion that impacts on the typical rural landscape of central Italy, although the master plan of Rome has the aim of protecting it. On the other hand, the work of Hewitt and Escobar (2011) used three Coordination of Information on the Environment (CORINE) Land Cover maps (from 1990 to 2006), to describe the fast urban growth produced in 19 municipalities included in a subregion of the Autonomous Community of Madrid. They conclude that this intensive process of urbanization due to the lack of planning control was mainly detrimental to agricultural land and natural grassland, causing unsustainable development and requiring new policy initiatives to avoid it. Finally, no similar studies have been found for Catalonia.

The objective of this article is to analyse the spatial and socio-environmental consequences at the local level of applying the GSPC, using a multivariate statistical analysis. Specifically, the goal is to understand the spatial dynamics of the GSPC with respect to all the Catalan municipalities from the 1980s to 2009. Although similar approaches have been used in previous studies, as mentioned above, this study contributes in three aspects. First, our work is based on an empirical case showing the spatial implications of regional planning from a dynamic perspective, using a synthesizing methodology and taking into account a high number of variables and municipalities. Second, both socioeconomic and geographic variables, the latter extracted from a Geographical Information System (GIS), have been introduced (Serra *et al.*, 2008). This approach allows the combination of information provided from different sources and more robust evaluation of spatial planning. Therefore, instead of analysing a specific spatial topic (industrial agglomeration, for example), this study analyses general trends of regional planning and their consequences at local scale. The third contribution, detailed in the Methodology section, corresponds to the innovative multivariate statistical analysis applied that allows advanced comparisons of municipal changes.

Study Area

In Spain, four layers of government exist: the national (state) government, the autonomous community, the provincial government and the municipality, which corresponds to the local level of government (town or city council) (Giordano & Roller, 2003). This local level corresponds to NUTS-5, the French acronym for Nomenclature of Territorial Units for Statistics, and it is equivalent to *communes* in France or *municipios* in Spain. The study area comprises the 946 municipalities included in the Autonomous Community of Catalonia (Figure 1). In this research the local level seems the most appropriate scale of work because there are only four provinces in the study area. Catalonia is located in north-east Spain, with a total surface of 32,000 km^2. About 79.9% of municipalities have fewer than 5000 inhabitants in contrast with the largest municipality and capital city, Barcelona, with 1.6 million inhabitants (Statistical Institute of Catalonia, 2011). Catalonia is delimited in the east by the Mediterranean Sea, in the north by France and in the west and south by the autonomous communities of Aragón and València, respectively. This strategic situation has favoured intensive socioeconomic relationships with other Mediterranean countries and with continental Europe.

Catalonia has a varied orography (Figure 1). The most relevant relief features are the Catalan Pyrenees (located in the north, being the highest mountain of 3140 m), the Pre-Pyrenees, the Ebre Depression (in the south), the Catalan Mediterranean system and the coast (in the east). The coast system is characterized by variability, with large flat areas, long sandy beaches and abrupt rocky shores with high cliffs (Sardà *et al.*, 2005). Especially along the coast, the climate is typically Mediterranean, mild in winter and warm in summer. The Pyrenees mountains have a high-altitude climate, with minimum temperatures below 0°C, annual rainfall above 1000 mm and snow during the winter. Far from the sea, the inland climate of Catalonia is continental, with cold winters and very hot days in summer.

Catalonia has a diversified economy based on small, mostly family-owned, firms and large multinationals. In 2008, the primary sector employed a low number of workers (about 3.7%) although 26.7% of the total Catalan surface is occupied by agriculture (Statistical Institute of Catalonia, 2011). In some subsectors it competes globally, as in the case of wine, pork or fruit. On the other hand, the industrial sector is very important, with 53.6% of workers, and is based on manufacturing, construction, chemicals and cars and accessories, among others. Finally, in the tertiary sector, which occupies about 42.6% of workers, advertising and new technologies are highlighted, but the sector especially relies on tourism: Catalonia, the most visited region of Spain, receives about 15 million foreign tourists each year. As a consequence of topographical relief and historical processes, the main spatial dynamics are associated with urban growth, especially near the metropolitan areas and in municipalities with mass tourism along the coast.

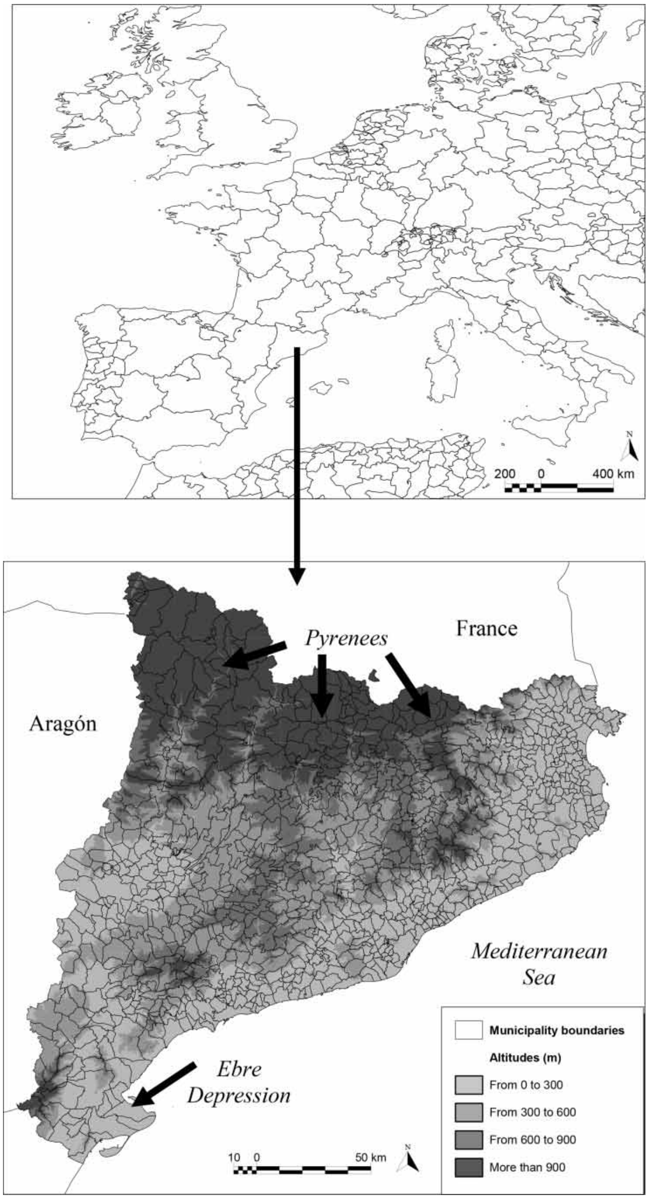

Figure 1. The upper map shows the regional division of the Western Mediterranean and the location of the study area, Catalonia, situated in the north-east of Spain. It has 946 municipalities with a diverse orography as shown in the lower map. The low altitudes, located on the coast and inland, are shown in light grey whereas the high altitudes, mainly located in the Pyrenees, are coloured in bright grey.

Catalan Regional Planning

In the context of Spain's autonomous communities, Catalonia represents a paradoxical case because it has a strong culture of territorial and urban planning (Marshall, 1995). Territorial planning is quite well developed due to the great weight of Barcelona as the administrative capital and to the presence of major transport routes to Europe and to the rest of Spain (Keating, 2001). Important local and metropolitan projects in Barcelona began early, with the Metropolitan Planning of 1976. Historical examples of regional planning include the Rubió and Tudurí Regional Planning developed in 1932, the Macià Plan of 1934 and the 1935 Public Works Plan (see for more details Wynn, 1984).

The Generalitat of Catalonia began preparing a territorial plan for the whole of this autonomous community in 1980 (and projecting until 2026, a remote time horizon). The GSPC was approved in 1995 for the development of seven Partial Spatial Plans (PSPs), each of them corresponding to a Catalan subregion, and the subsequent urban development plans (Catalan Society of Planning, 2003). The primary aim of the GSPC was demographic, proposing a distribution of population (for the year 2026 of 7.5 million; currently the population is about 7.3 million) by identifying growth zones around the congested metropolitan system of Barcelona, in order to reduce population pressure. The main zones of expansion were around the municipalities of Martorell, Mataró, Vilanova i la Geltrú, Granollers and Cardedeu (Figure 2). This distribution model corresponds to a polycentric urban region as the large urban centre (the municipality of Barcelona with a population density of 15,943 inhab/km^2 in 2008) expands its commuting area, incorporating the five medium-sized cities mentioned, which had been self-sufficient in terms of employment and services (Muniz *et al.*, 2003). Other areas with scope for growth were the municipalities around Tarragona, Lleida and Girona, the other provincial capitals together with Barcelona (Figure 2). In the GSPC, these were considered small metropolitan regions with a high potential for demographic and economic growth. On the other hand, some coastal zones, characterized by tourism activity, were placed in a separate category with the aim to avoid the congestion associated with excessive urbanization. Finally, the GSPC planned to impede the depopulation of mountain areas, which had reached nearly 10% in the preceding decades. To achieve these demographic goals, the second main objective focussed on the improvement of infrastructures, differentiating those associated with transport, services and communications. The goal was to increase public transport, improve access to the existing and new roads network, including the Transversal Arterial Road, and to promote the airport and port of Barcelona. The third and final key objective of GSPC was to improve the welfare of the population with a suitable number of educational, sanitary, cultural and sport installations. From an environmental point of view, the main GSPC objectives were to preserve the most interesting areas from a natural and landscape point of view, to decrease the atmospheric pollution and the urban and industrial solid waste and, finally, to develop environmental impact studies (Generalitat de Catalunya, 1995).

On the other hand, the seven PSPs were finally approved from 2006 to 2010. In each of them three main systems were differentiated: open spaces, urban settlements and mobility infrastructures (Nel·lo, 2012). The main objectives akin to open spaces were to encourage land diversity and maintain the ecosystems, to protect natural areas and agricultural development, and to preserve the landscape as a social value and heritage. In relation to the settlements, the key objectives were to strengthen the territory nodal structure through

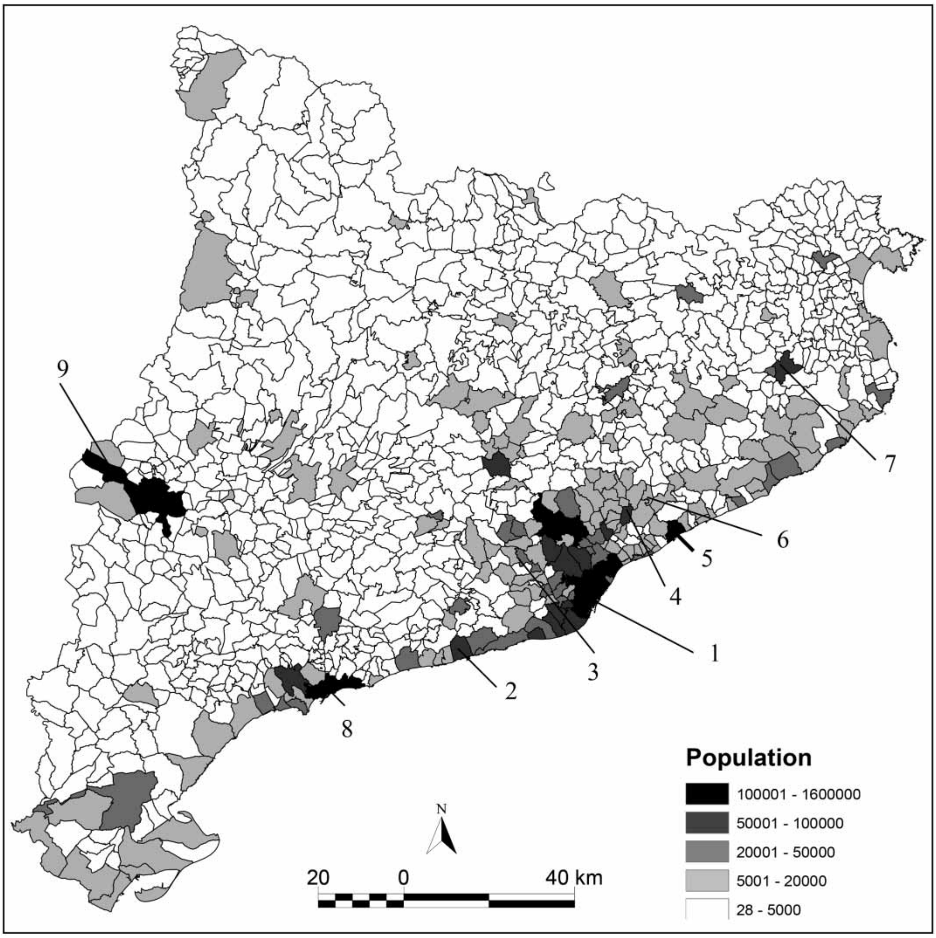

Figure 2. Distribution of Catalan population by municipalities. Numbers correspond to the location of the following cities: 1. Barcelona; 2. Vilanova i la Geltrú; 3. Martorell; 4. Granollers; 5. Mataró; 6. Cardedeu; 7. Girona; 8. Tarragona; 9. Lleida.

urban growth and promote the compactness of new growth areas. Finally, in the case of mobility infrastructures one of the main goals was to emphasize the road network to structure the territorial urban development.

Methodology

Data Description

As asserted before, the objective of this article is to analyse Catalan territorial dynamics resulting from the GSPC and PSPs. Three study periods were defined, based on available data: the 1980s, the early 2000s and 2009 (the most recent statistics), analysing exactly the same variables for all three periods. Table 1 summarizes the 30 socioeconomic and geographic variables considered in this study and provided by different sources at municipal

Table 1. Variables included in factor analysis for 1980s, early 2000s and 2009, according to their source

Extracted from the Statistical Institute of Catalonia	
TP	Total population
IA	Industrial area (in ha)
CA	Commercial area (in ha)
SA	Services area (in ha)
MR	Dwellings (main residences)
SR	Secondary residences
LPT	Local property tax
HC	Hotel capacity
CC	Camping capacity
AW	Agricultural workers
IW	Industrial workers
CW	Construction workers
SW	Service workers
Extracted from agrarian censuses (INE, 1991, 2002 and 2011)	
NF	Number of farms
NAF	Number of agricultural fields
DAA	Dry agrarian area (in ha)
IAA	Irrigated agrarian area (in ha)
DHA	Dry herbaceous area (in ha)
IHA	Irrigated herbaceous area (in ha)
FA	Forest area (in ha)
PPA	Permanent pastures area (in ha)
NL	Number of livestock
Extracted from a GIS	
AWS	Areas without water shortage
ALT1	Low altitude (from 0 to 300 m)
ALT2	Medium altitude (from 300 to 600 m)
ALT3	High altitude (more than 900 m)
ALT4_SL3	Medium-high altitude and slope (from 600 to 900 m and from 12.1 to 25°, respectively)
SL1	Low slope (from 0 to 3°)
SL2	Medium slope (from 3.1 to 12°)
SL4	Deep slope (more than 25.1°)

level. The selection of variables was based on previous works (Pallarès *et al.*, 2003) and the variables used in the GSPC memorandum (Generalitat de Catalunya, 1995). Because we analysed data from three periods of time, some variables were excluded due to the lack of data in all of them or in a particular period because this was equivalent to break the time series of original variables (for example, house prices or gross domestic product (GDP) per capita were not available in the 1980s) or due to the high level of correlation between them (very close to 1), as in the case of total population and public welfare installations (number of hospital beds or libraries, for example).

Variables related to population and labour, economy, urbanization and tourism, agrarian information and geographic data were included. Population and labour data were obtained from the Statistical Institute of Catalonia, including total population; total surface occupied by industries, commerce and services (in hectares); main and secondary residences;

local urban property tax; hotel and camping capacity; and total number of workers by sectors. These data were introduced with the objective of differentiating those municipalities weighted toward agriculture, industry or services, especially tourism. Agrarian information was obtained from the agrarian censuses of 1989, 1999 and 2009 (INE, 1991, 2002, 2011, respectively). These years were chosen to compare the available census data in Spain. The nine variables included were the number of farms, number of agricultural fields, dry (non-irrigated) agrarian area, irrigated agrarian area, dry and irrigated herbaceous area, forest area, area of permanent pastures and number of livestock (cattle heads). The objective of such inclusion was to identify the level of specialization in agriculture, livestock or forest uses for the municipalities studied. Finally, four specific geographic variables were extracted from GIS to characterize the diverse orography of Catalonia: precipitation, areas without water shortage, altitude (extracted from a digital elevation model (DEM) with a pixel size of 20 m × 20 m, provided by the Cartographic Institute of Catalonia) and slope (generated from DEM). Intervals were generated on the basis of published results cited above.

Statistical Analysis

Factor analysis (FA) and principal component analysis are among the most common statistical methods applied in planning and socioeconomic studies (Nunes, 2002; Pierangeli *et al.*, 2008; Monastiriotis, 2009; Nosvelli & Musolesi, 2009; Ribeiro & Lovett, 2009). The objective of FA is to obtain comprehensible new factors that express the essential information contained in a set of variables. Each of those variables is represented as a linear combination of a smaller set of common factors plus a unique factor assigned to each of the original variables (Afifi & Clark, 1996). The equation is:

$$X_1 = w_{F_1} + w_{F_2} + \cdots + w_{F_p} + u_1 \tag{1}$$

where X_1 is the standardized original variable, w the factor loadings of F_p common factors that describe the linear combination, and u_1 the unique factor specific to each original variable. The four steps used in FA include a correlation test of original variables, extraction of common factors, computation of a factor matrix and calculation of factor score coefficients.

Two different tests were calculated to assess the first requirement; the original variables must be correlated in order to share common factors. The tests were the Measure of Sampling Adequacy (MSA) and the Kaiser-Meyer-Olkin (KMO). The MSA compares the correlation coefficients with the partial correlation coefficients for each original variable whereas KMO is a global test of the model and requires values above 0.6 to be considered appropriate for factor analysis (Norušis, 1994).

Once these tests allowed FA to proceed, the next step was the extraction of common factors, according to the eigenvalue criterion (namely, the variance explained by each common factor, being gradually smaller from the first to the last), usually greater than 1 because the variance of a standardized variable is equal to 1 (Hakstian *et al.*, 1982). The next indicator was communality, indicating the proportion of variance among original variables explained by the selected common factors. Values near 1 indicate that common factors retained the main information of original variables; values near 0 indicate the opposite.

The third step was to obtain the factor matrix that shows the weight of each retained common factor in relation to each original variable, a value known as factor loading.

These values can be near +1 or −1, reflecting a high weighting, or near 0, indicating little relationship. To obtain a more defined factor matrix that is easier to interpret, a common operation is to rotate the factor matrix using, as in our case, the Varimax rotation, an orthogonal rotation of each factor intended to get high loadings in just a few variables and the rest near 0 (Norušis, 1994).

The last step was to calculate the final values for each common factor and municipality using factor score coefficients. To analyse regional changes over a period of time (5, 10, 15 or 20 years, for example), usually the comparison is made after applying different (and individual) FA as in Burinskienė and Rudzkienė (2004). Nevertheless, this option may complicate the interpretation of results because the number of main factors and their loadings can change from one time period to another (as happened when we tried this option) and therefore the comparison becomes meaningless. Consequently, once the factor score coefficients from the 1980s were obtained, they were applied to the standardized original variables from the early 2000s. The equation to quantify the value for each factor from the 1980s was:

$$F_1 = s_1^{t_1} x_1^{t_1} + s_2^{t_1} x_2^{t_1} + \cdots + s_p^{t_1} x_p^{t_1}, \qquad (2)$$

where F_1 is the corresponding value of the first common factor for a given individual, $s_p^{t_1}$ are the factor scores corresponding to p original variables $x_p^{t_1}$ from the 1980s. The following equation was used to calculate the factor score coefficients for the 2000s data:

$$F_1 = s_1^{t_1} x_1^{t_2} + s_2^{t_1} x_2^{t_2} + \cdots + s_p^{t_1} x_p^{t_2}, \qquad (3)$$

where F_1 is the corresponding value of the first common factor for a given individual, $s_p^{t_1}$ are the factor scores corresponding to the 1980s and $x_p^{t_2}$ are p original variables for the early 2000s.

After obtaining the corresponding results for the early 2000s and for 2009, to synthesize the analysis of changes and to avoid examining an excessive number of maps (six for each period, 18 in total) the next step was to apply a clustering method with the objective to group municipalities with similar dynamics. The process consisted of calculating from the retained common factors a number of clusters that would group them according to the Euclidean distance. The algorithm corresponded to *k*-means, a non-hierarchical clustering that places the initial group centroids into the space (MacQueen, 1967). The next step was to assign each case (in our work, a municipality) to the group that had the closest centroid; when all the cases were assigned, the position of the *k* centroids was recalculated. The last step was to repeat the process until the centroids no longer move. A requirement of *k*-means is to establish the number of clusters to be obtained, six in our case, a third of the total common factors analysed, as we will see in the next section.

Results and Discussion

Spatial Dynamics

Factor analysis for the 1980s showed the following results: the MSA values for all the variables were above 0.5 and the KMO value was 0.8. These results validated the application of FA because the original variables were sufficiently correlated to share common factors. Table 2 summarizes the total explained variance of the six first common factors retained in

Table 2. Explained variance of the six first common factors extracted from 1980s variables and rotated factor loadings from the six first common factors (F) extracted from 1980s data

	F1	F2	F3	F4	F5	F6
Eigenvalue	9.1	5.4	3.4	2.9	2.1	1.9
% variance	30.3	18.0	11.3	9.7	7.0	6.3
Cumulative % variance	30.3	48.3	59.6	69.3	76.3	82.6
Variables	Urbanization	Irrigation	Pastures	Dry agriculture	Forest	Tourism
TP	**0.993**	0.039	−0.004	0.000	0.001	0.041
IA	**0.933**	0.060	−0.034	−0.008	−0.028	0.039
CA	**0.989**	0.065	−0.006	0.001	−0.002	0.074
SA	**0.980**	0.058	−0.003	−0.003	−0.002	0.109
MR	**0.990**	0.033	−0.002	0.002	0.003	0.039
LPT	**0.984**	0.069	−0.011	−0.008	−0.007	0.133
IW	**0.988**	0.036	−0.014	−0.006	−0.008	0.027
CW	**0.930**	0.130	−0.021	−0.028	−0.020	0.139
SW	**0.986**	0.038	−0.001	0.002	0.003	0.054
NF	−0.004	**0.813**	−0.006	0.235	0.097	0.149
NAF	−0.059	**0.724**	0.120	0.440	0.081	0.057
IHA	0.000	**0.870**	−0.015	−0.162	−0.032	−0.112
IAA	0.002	**0.928**	0.000	−0.154	−0.033	−0.072
ALT1	0.162	**0.750**	−0.100	0.017	−0.005	0.265
NL	−0.012	**0.626**	−0.053	0.210	−0.098	−0.237
AW	0.243	**0.846**	−0.016	0.068	0.008	0.155
SL1	0.145	**0.902**	−0.016	0.166	−0.109	0.078
ALT3	−0.020	−0.050	**0.849**	−0.082	0.434	−0.030
AWS	−0.014	−0.064	**0.908**	−0.109	0.220	−0.018
SL4	−0.008	−0.006	**0.703**	−0.028	0.526	−0.068
PPA	−0.007	−0.044	**0.897**	0.095	−0.143	0.034
DAA	−0.041	0.174	0.664	**0.677**	−0.106	0.050
SL2	0.034	0.209	−0.013	**0.810**	0.394	0.052
ALT2	−0.015	0.067	−0.136	**0.790**	0.229	−0.082
DHA	−0.015	0.080	0.016	**0.750**	−0.025	−0.102
ALT4_SL3	−0.015	−0.063	0.171	0.422	**0.756**	−0.023
FA	−0.022	−0.051	0.258	0.153	**0.873**	−0.018
SR	0.416	0.070	−0.011	−0.035	−0.028	**0.777**
HC	0.501	−0.006	0.009	−0.015	0.005	**0.557**
CC	−0.025	0.094	−0.016	−0.084	−0.032	**0.832**

Notes: See Table 1 for a description of variables. In bold, the highest positive factor loadings for each variable according to the six first common factors retained.

our analysis. They were retained following an eigenvalue criterion, being greater than 1, as explained above. The total variance explained with them was 82.6%, a percentage that we considered high enough for our study objectives. All the commonalities showed values above 0.5, with the lowest values corresponding to the number of livestock and hotel capacity, and the highest to local urban property tax and total population.

As indicated above, Table 1 summarizes the name of original variables and their acronyms included in the analysis. Table 2 shows the rotated factor loadings of the six first common factors, using these acronyms. The first common factor, with a total variance of 30.3%, showed high factor loadings with variables related to area of industries, commerce and services, main residences, local urban property tax, industrial, service and construction workers and finally, total population. This first common factor was labelled as "urbanization" because it included economic activity corresponding to urbanized areas and total population. Figure 3 shows the municipalities with the highest factor loadings akin to urbanization. As one can see, they were located around the provincial capitals of Barcelona, Girona, Tarragona and Lleida, and other municipalities highly correlated with the presence of some main roads as shown in the map. Nevertheless, a few exceptions appeared on the coast, due to the presence of tourism activities, and in the inner part of Catalonia, due to the construction of the Transversal Arterial Road. As an example of mobility infrastructure improvement, this roadway was inaugurated in 1997 with the aim of directly connecting the provincial capitals of Girona and Lleida, avoiding Barcelona.

The second common factor, with a total variance of 18% (Table 2), showed high factor loadings with variables akin to the number of farms, number of agricultural fields, irrigated herbaceous area, irrigated agrarian area, low altitude, number of livestock, agricultural workers and low slope from 0 to 3°. In consequence, this common factor was labelled as "irrigation agriculture". In the corresponding final map not included in this article for avoiding an excessive number of figures as mentioned before, one can see the most irrigated agricultural areas of Catalonia, located in the north-east, south and east.

The third common factor, with a total variance of 11.3% (Table 2), showed high factor loadings with the following variables: high altitude and deep slope, areas without water

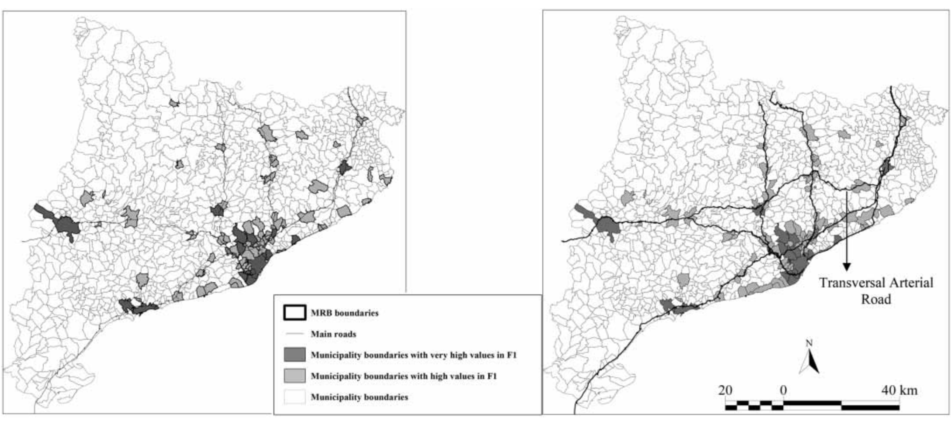

Figure 3. Changes in the first common factor (F1, labelled as "urbanization"), shown in 1980s (left) and 2009 (right) for the entire study area.

shortage and permanent pastures. Consequently, this common factor was labelled as "permanent (or perennial) pastures and scarce population", characterized by being located in mountainous municipalities. The corresponding map (not shown) showed an elevated specialization in the Pyrenees, pre-Pyrenees and in the mountainous area of the River Ebre.

The fourth common factor, with a total variance of 9.7%, showed high factor loadings with dry agrarian area, medium altitude and slope and dry herbaceous area. Therefore, this common factor was labelled as "dry agriculture and scarce population", located in municipalities with a high specialization in dry agriculture (mainly cereals) simultaneously with a low level of population. They were located in the inner part of Catalonia and in the south. The fifth common factor, with a total variance of 7%, was related to medium-high altitude and slope and forest area (FA). As a result, this common factor was labelled as "forest". The predominant location was in those municipalities with a large surface and mainly situated in the Pyrenees and in the coast. Finally, the last common factor, with a total variance of 6.3%, was akin to hotel and camping capacity and secondary residences. For this reason, this common factor was labelled as "tourism".

As mentioned before, in order to perform an acceptable comparison between periods, the same factor score coefficients calculated from the 1980s were applied to the same variables for the early 2000s and 2009 data, as shown in Equation (3), obtaining the corresponding values for urbanization, irrigation agriculture, pastures, dry agriculture, forest and tourism. The right map of Figure 3 shows the results for 2009 according to F1 (labelled as "urbanization") that can be compared with the 1980s results. The main visible characteristic of this figure is the expansion of those municipalities closest to main roads. A few exceptions, far from the main Catalan roads, corresponded to capitals of counties. Figure 4 is a zoom of the Metropolitan Region of Barcelona (MRB). In the centre of the MRB the results are similar between 1980s and 2009 whereas the main urban increases appear around the AP7 highway (to the east from Barcelona city).

The rest of dynamics was examined using cluster analysis, as mentioned above, being six the total number of required clusters. Table 3 shows the final cluster centres from the 18 common factors and the number of municipalities assigned to each cluster. The highest positive values indicate common factors that are clearly included within a cluster, whereas the most negative indicate the opposite. Cluster one corresponds to those municipalities with a high weight (with positive sign) in pastures (F3) and in forest (F5),

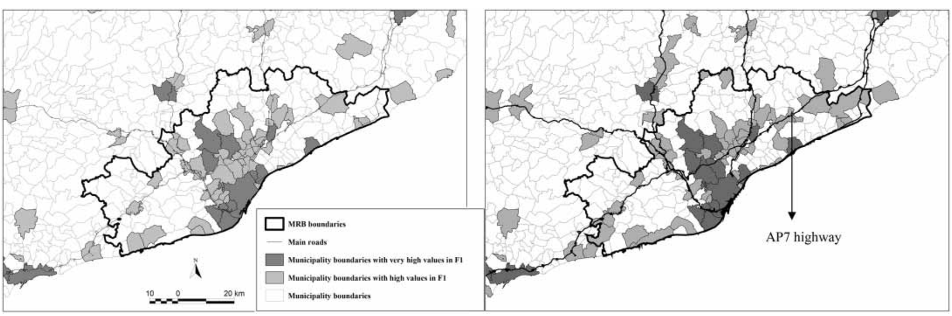

Figure 4. Changes in the first common factor (F1, labelled as "urbanization"), shown in 1980s (left) and 2009 (right) around the MRB.

therefore it was labelled as "pastures and forest land". They were located in the northwest of the study area, frequently as a consequence of an agricultural abandonment process (Barrachina & Tulla, 2010) (Figure 5). The main characteristic of these municipalities was the large extension of their administrative boundaries, situated in the highest mountain areas of Catalonia (around Pyrenees and Pre-Pyrenees).

The coefficients of cluster 2 showed those municipalities (684 cases) "without any significant change" because none of them was high nor positive (Table 3). Consequently, the majority of Catalan municipalities (72.3% of total) did not show a significant change in the studied period. They were located throughout Catalonia (trending toward the northeast) and given the high number of cases, they were not mapped. On the other hand, cluster 3 shows those municipalities, 10% of total, with a high weight in "dry agriculture" (F4) and with negative coefficients in urbanization and tourism (F1 and F6, respectively). According to Figure 5 they were mainly located in the centre and south of Catalonia where the presence of dry winter cereals is very significant. Conversely, cluster 4 was labelled as "irrigation agriculture" due to the high weight of factor 2 in all the study periods. The five municipalities included in this cluster were located in areas with ready availability of water. Concretely, these areas are around the Ebre River delta (in the south) with a large extension of rice farming, and in the inland area near Lleida, with important extensions of herbaceous and fruit trees.

Cluster 5 was labelled as "municipalities with an increasing specialization in tourism" because the tourism factor (F6) showed very high positive values. An important characteristic of all these municipalities is that they preserved a slight rural activity, mainly irrigation agriculture (positive values in F2). Figure 5 shows that they were only located on the coast and this phenomenon was continuous around the Catalan shoreline with the exception of the MRB, in the centre of the map. As seen in Figures 3 and 4, in the MRB the high weight of urbanization was akin to main residences instead of tourism, and in the south with a high weight of rural activities.

Finally, cluster 6 was labelled as "rural municipalities with some tourism activities" due to the high weight of pastures and dry farming (F3 and F4) and of tourism (F6). Figure 5 shows that just two municipalities corresponded to such situation, located in the northwest of Catalonia, in the Pyrenees.

Socio-environmental Consequences

According to our results, it seems that one of the GSPC objectives, to avoid more congestion in Barcelona by expanding the urbanization around medium-sized cities, was being accomplished (Figures 3 and 4). This process of dispersed and horizontal urban expansion instead of vertical growth, known as urban sprawl, is a phenomenon much more recent in Catalonia than in other areas of the world, like North America (Catalán *et al.*, 2008). As a result of the extensive land occupation, urban sprawl has some socio-environmental consequences (European Environment Agency, 2006): one is the important decrease of forest and agricultural land, producing a loss of natural habitats and corridors in the MRB. In Mediterranean landscapes, extensive agro-forest mosaics are the second habitat in terms of vertebrate diversity, after wetlands (Institució Catalana d'Història Natural, 1999), and as Mallarach and Marull (2006) assert that rapid urban growth has been the main cause of habitat and landscape fragmentation in the MRB. Similar consequences have been analysed in France, Italy and Greece, among other Mediterranean countries or regions (Moriconi-Ebrard, 2001).

Given the increasing importance of residential uses and the expansion of transport infrastructures, a second socio-environmental consequence of sprawl is the increase of traffic jams that augments atmospheric pollution. This fact is aggravated by the progressive segregation of commercial and industrial uses, causing an intensification of human mobility with a high dependence on private automobiles producing more ubiquitous pollution (Querol *et al.*, 2001). Therefore, in the face of the increasing traffic pollution, the Generalitat of Catalonia has defined various measures within an air quality action plan. One of these is the recent introduction of a maximum 80 km/h speed limit in some MRB highways.

Another consequence of urban sprawl is the homogenization of urban environments and the standardization of urban landscapes, a process known as "urbanalization" (Muñoz,

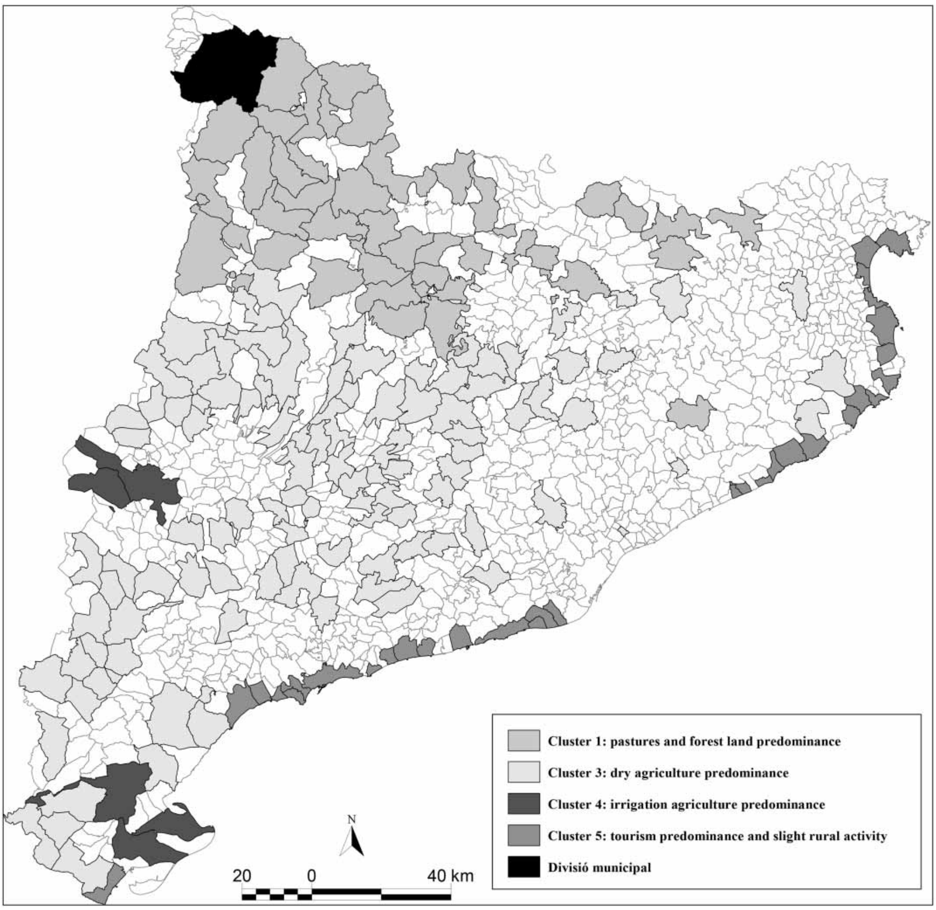

Figure 5. Map of clustering results corresponding to those municipalities with an increased specialization in pastures and forest land, in dry agriculture, in irrigation agriculture, in tourism and in tourism and rural activities.

Table 3. Final cluster centres for each common factor and period of time: 1980s, early 2000s and 2009

		Cluster					
		1	2	3	4	5	6
Factor and year	Label	Pastures and forest land	Without changes	Dry agriculture without urban and tourism increase	Irrigation agriculture without tourism activities	Municipalities specialized in tourism	Rural municipalities with tourism activities
F1_1980s	Urbanization	−0.07	−0.03	−0.06	0.08	−0.05	0.06
F2_1980s	Irrigation	−0.18	−0.11	0.34	9.36	0.16	−0.54
F3_1980s	Pastures	2.11	−0.14	−0.16	0.18	−0.21	14.57
F4_1980s	Dry agriculture	−0.61	−0.23	2.03	−0.85	−0.35	2.20
F5_1980s	Forest	2.36	−0.19	0.47	0.59	−0.24	−3.58
F6_1980s	Tourism	−0.20	−0.16	−0.11	−0.22	4.38	1.04
F1_e2000s	Urbanization	−0.11	−0.02	−0.07	0.13	−0.03	0.04
F2_ e2000s	Irrigation	−0.19	−0.09	0.45	9.11	0.17	−0.33
F3_ e2000s	Pastures	3.96	−0.34	0.54	0.69	−0.53	13.40
F4_ e2000s	Dry agriculture	−0.13	−0.25	2.02	−1.05	−0.45	1.03
F5_ e2000s	Forest	1.53	−0.17	0.59	0.70	−0.18	−1.23
F6_ e2000s	Tourism	0.01	−0.15	−0.11	−0.21	3.98	1.07
F1_2009	Urbanization	−0.10	−0.02	−0.07	0.11	−0.04	0.03
F2_2009	Irrigation	−0.18	−0.11	0.55	8.98	0.18	−0.32
F3_2009	Pastures	2.73	−0.16	−0.19	0.15	−0.30	14.47
F4_2009	Dry agriculture	−0.27	−0.18	1.59	−0.85	−0.35	2.38
F5_2009	Forest	1.75	−0.17	0.52	0.57	−0.21	−4.35
F6_2009	Tourism	0.04	−0.14	−0.16	−0.98	3.82	1.23
Number of municipalities		41	684	95	5	29	2

2005). Consequently, urban areas become increasingly similar in their physical landscapes, atmosphere and lifestyles. This is particularly true in the expansion of single-family housing, characteristic of urban MRB increase. At the same time, the Catalan urbanization model shows wide areas with low levels of population, mainly in mountain areas, and especially in the 2000s as a result of an uneven development. In this sense, the inauguration of the "transversal arterial road" in 1997 to connect inland cities such as Girona and Lleida was a step to avoid the radiality of Barcelona. As a consequence of depopulation, forest and brush recovery is increasing in the Pyrenees due to the abandonment of agricultural activities and the subsequent low population levels (MacDonald *et al.*, 2000). Simultaneously, these areas have experienced an institutional "reterritorialization" because they include the largest protected areas (natural parks, etc.), causing an increase of tourism activity and, in consequence, slight recovery of population (Molina, 2002; Vaccaro & Beltrán, 2009). In our work, this fact is clearly shown in Figure 5 where two mountainous municipalities presented a high touristic infrastructure.

In the case of tourism, three processes are visible. The first is that tourism is a coastal phenomenon in Catalonia (Figure 5). This feature also applies to Spain and to Mediterranean countries in general, due to tourism based on sun and sand (Ivars, 2004). As the Blue Plan asserts (Moriconi-Ebrard, 2001), the process of concentrating population and economic activities in coastal spaces is known as "coastalization". In many cases this development has been much criticized because the model produces excessive congestion on the coast, a gradual decrease in landscape diversity and complexity, and increased vulnerability to certain hazards such as floods and droughts (Greenpeace, 2008). The second process is that around the northeast of Barcelona, and as a consequence of MRB decongestion, there is an interruption in the tourism-related coastal congestion. As a result, some municipalities have transformed their tourist infrastructure into main residences (Figure 5). Finally, some Pyrenees municipalities have heightened their profile as tourism attractors, including adventure activities taking advantage of the sky, mountains, valleys and rivers, and visits to natural protected areas.

Strengths and Weaknesses of the Methods Used

From a methodological point of view, the process applied in this study (factor analysis and clustering) has produced interesting results even though building dynamic models that compare data from more than one year is a difficult task (Burinskienė & Rudzkienė, 2004). The method used in this study depends on the initial variables included in the analysis and their number, requiring that more than one original variable be associated with each factor. Another important issue to be mentioned is the number of observations; it is recommended to use a sample size at least twice the number of initial variables (Kline, 2002). This study analysed 946 municipalities, more than 30 times the initial 30 variables. Finally, a crucial parameter in factor analysis is the rule for deciding the number of factors to be retained. The option adopted in this work was the Kaiser-Guttman rule, where the eigenvalues should be greater than unity, the most-used choice according to Hakstian *et al.* (1982).

On the other hand, an important result to discuss is akin to the high number of municipalities (684 cases) labelled as "without any significant change" (cluster 2). From our point of view, this could be explained by the original variables included in the analysis. At least three reasons can be differentiated. First, the exclusion of urban areas and municipalities with industrial and mining activities in crisis, in general located at the centre-north of Catalonia. In our model, the industrial data (area and number of workers) were included in the first FA, highly correlated with population and urbanization, as described earlier. A second group of municipalities included in cluster 2 could correspond to low (or negative) increase of population and to agrarian areas in crisis. Finally, a third situation could include those municipalities with a strong weight of feedlot cattle and, therefore, not be associated with pastures or cropland. An additional reason for such a high number of municipalities without changes may be the variance unexplained by our FA analysis. In fact, 82.6% of variance is explained by the six factors retained, but the remaining 17.4% may include some of the three situations described here.

Despite these possible methodological weaknesses, our work reveals the main general dynamics of regional planning and their local consequences during the periods analysed in the case of Catalonia. We must emphasize "main general dynamics" because our work does not discard that spatial planning is a complex process and, in consequence, territorial changes depend on many different driving forces at diverse tiers of administration. In this sense, the integration of Europe and the territorial decentralization of Spain (among other facts) have produced that the decision making competences are shared with a variety of actors and institutions at supranational, national and subnational levels (Hooghe, 1995), in agreement with the concept of multi-level governance (Marks, 1992). Nevertheless, this term surpasses the objective of this study and will be analysed in future research.

Conclusions

In this article a reliable statistical analysis was applied to evaluate the impact of regional planning dynamics on Catalan municipalities from the 1980s to 2009. Factor analysis was used as a tool for the reduction of 30 variables, obtaining six common factors for the 1980s that explained 82.6% of total variance. The dynamics of change were then analysed, applying to early 2000s and 2009 data the same factor score coefficients from the 1980s. This methodology avoided calculating a new factor analysis for 2000s variables, which would have made no sense for purposes of comparison. Therefore, with just one factor analysis the real dynamics from 1980s to 2009 were robustly obtained. The next step was to apply a clustering technique to synthesize the 18 maps obtained, six common factors for each period, and group those municipalities with the same dynamics in six final clusters.

From among the original objectives of the Catalan regional planning effort, in this work some general issues have been analysed: distribution of population and communications infrastructures and socio-environmental consequences related to landscape and atmospheric pollution. Our work summarizes five dynamics from the 1980s: decongestion or urban sprawl, urbanalization, depopulation, reterritorialization and coastalization. The decongestion of Barcelona has produced major urban sprawl around the Metropolitan Region. The socio-environmental consequences of such dispersion have been analysed, namely, increased mobility, traffic jams and atmospheric pollution. Second, depopulation occurred in the Catalan Pyrenees and some inland municipalities with a high presence of dry farming. Whereas in the Pyrenees some processes of reterritorialization linked to protected areas and tourism activities have appeared, in the dry-farming municipalities the depopulation is linked to the lack of new road infrastructures such as the "transversal arterial road". In this sense, the population concentration in the main towns (administrative centres such as provincial or county capitals) seems to be a detriment contributing to the depopulation of municipalities with a less robust communications network. The third phenomenon, the objective of reducing coastalization, was a failure as the 2000s results show. Nevertheless, as asserted in the introduction, the GSPC had a remote time horizon (until 2026) and efforts to meet the objectives are still being implemented. Therefore, more analysis should be done over time, using new census data to compare emerging dynamics with our results.

In conclusion, the methodology applied in this work may be an example for understanding the weight of regional planning in Europe and for being an example to investigate spatial dynamics in other regions and countries around the world.

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