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Beyond urban–rural dichotomy: Exploring socioeconomic and land-use processes of change in Spain (1991–2011)

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ABSTRACT

In the last decades, the process of land-use intensification linked to human activity has changed considerably causing important modifications in the traditional dichotomized urban–rural relationships. Given their more complex dynamics, alternative methodologies for analysing the spatial consequences of changes are required. The present study investigates the variables shaping the urban–rural relationship in Spain over the last 20 years using a synthesizing methodology based on statistical and cartographic techniques that take into account a large number of variables and cases. The study was carried out at the level of local municipalities (nearly 8000 spatial units), fitting 36 socioeconomic and geographical indicators into a multivariate statistical framework. Indicators were selected to describe processes of intensification, extensification, or abandonment implying both land-use changes and important transformations in the local socioeconomic structure. Multivariate analysis identified seven processes contributing to the change in the urban–rural relationship in Spain: urban intensification and sprawl, coastalization, naturbanization, expansion of irrigated crop systems, livestock and pasture expansion, afforestation and reforestation, and depopulation. An in-depth understanding of recent spatial dynamics in Mediterranean countries may inform sustainable land management with the final aim to mitigate or re-balance the impact of these processes in land degradation or in an excessive human pressure along the coastal rim between other undesirable consequences.

Introduction

'Urban' and 'rural' are key – and typically dichotomized – concepts in regional science, being the study of both long- and short-term changes in the urban–rural relationship at various spatial scales one of the most important and traditional issues in applied geography. The intensive and extensive use of land, together with the spatial distribution of labour and capital in various economic activities, has changed dramatically in the last decades at both the global and local scales. For this reason, regional planning needs to take into account new and more complex relationships, together with the intensity of changes (Bengs & Schmidt-Thomé, 2007).

The process of intensification in the use of land has been logically connected to human activity through the analysis of land-cover and land-use changes. Urbanization may be considered an example of land intensification carried out through increased population density along the urban gradient due to settlement density and a higher vertical profile in urban areas. Together with traditional urbanization patterns (mainly compact expansion), the term "urban sprawl" has appeared, being defined as a scatter occupation of the territory by medium- and low-density settlements, occurring around the world but especially around metropolitan areas (Catalán, Saurí, & Serra, 2008; Salvati, Gargiulo, Rontos, & Sabbi, 2013) and possibly associated with a more intense use of private cars and exemplified by a settlement pattern dominated by detached houses (Halleux, Marcinczak, & van der Krabben, 2012).

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Urbanization may take on a different nature due to its driving forces, which are mainly associated with work and first residence or with tourism and second residence. In the latter case two processes can be differentiated, one related to the coastline, known as coastalization and defined as a procedure of concentrating population and economic activities along the coastal rim and in the immediate surroundings (Moriconi-Ebrard, 2001). The other process is related to the mountain sites, known as naturbanization and defined as the population de-concentration and its spread towards mostly rural and natural areas, which play an attractive role as places of leisure, second residence or even work; in many cases, the attraction is connected with protected areas and to winter activities (Prados, 2009).

On the other hand, land extensification is a process usually intended as the reverse pattern of intensification, primarily associated with (partial or complete) land abandonment and depopulation, and spatially concentrated in marginal, inland areas with a stagnant job market and elderly population. Cropland abandonment is a clear example of land extensification, and may occur in areas with a high urban pressure (around metropolitan centres) or as a result of depopulation in more isolated mountain areas with fewer economic activities (Corbelle-Rico, Crecente-Maseda, & Santé-Rivera, 2012; Sluiter & de Jong, 2007). Consequences of such a decline may be afforestation and reforestation, the regeneration of woodland as a result of ploughed fields or pastures abandonment (Chauchard, Carcaillet, & Guibal, 2007).

The methods and data used to analyse spatial changes in land intensification/extensification, taken as the most important transformations in the urban–rural relationship at a large scale, have been very diverse. According to data type, two main large groups may be differentiated: one is statistical records extracted from census or other statistical surveys, generally collected within administrative boundaries, which may be mapped using vector boundaries such as provinces/prefectures (Ayuda, Collantes, & Pinilla, 2010), municipalities (Serra, Vera, & Tulla, 2013), or districts of social or economic interest (Salvati, 2012). The second most common data type is extracted from aerial photographs or remote sensing images, with diverse pixel sizes (Feranec, Jaffrain, Soukup, & Hazeu, 2010). In this case, one advantage is that researchers may analyse land cover and land-use at any period of time if the corresponding image is available, whereas statistical records in some occasions do not offer the required temporal, spatial, and information precision. Despite recent improvement in research strategies, the most common technique for detecting spatial changes remains the overlay of different land-use-cover maps to reveal gains or losses, a process known as post-classification comparison or cross tabulation analysis (Hewitt & Escobar, 2011; Serra, Pons, & Saurí, 2003). Nevertheless, when socioeconomic variables are included in change-detection analysis, alternative methodologies for analysing spatial dynamics are required.

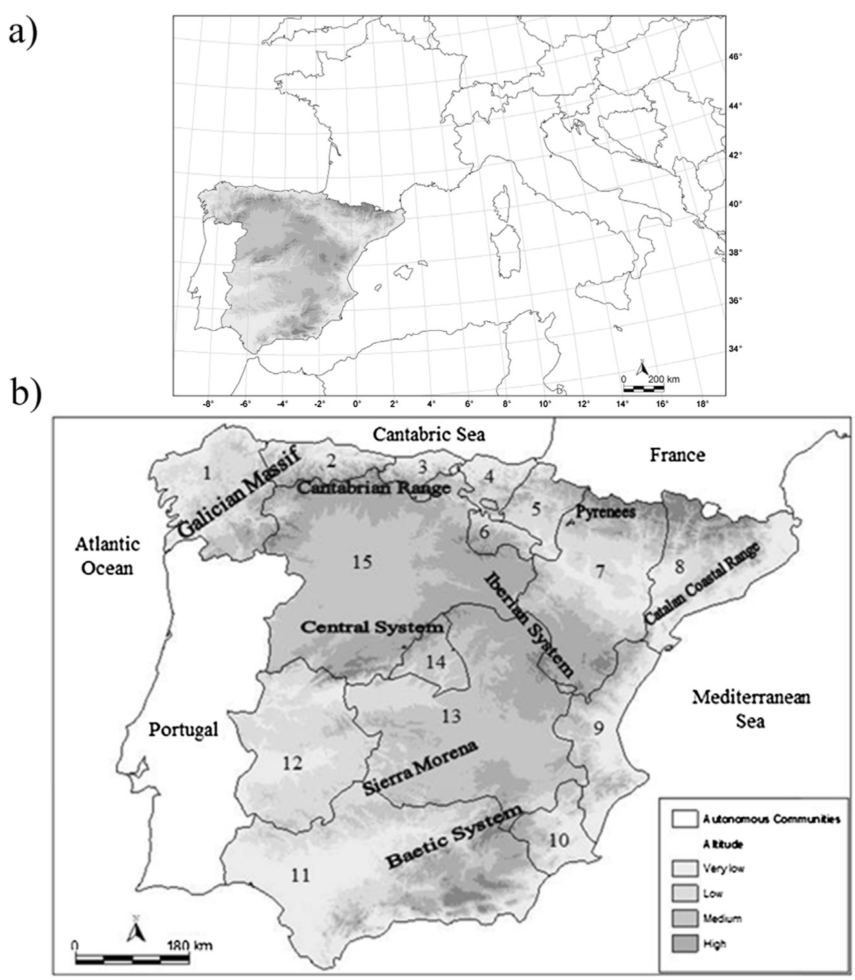

Fig. 1. a. Study area: Spanish Iberian Peninsula, located in the Western Mediterranean. b. Study area: Spanish Iberian Peninsula. Autonomous Communities: 1. Galicia, 2. Asturias, 3. Cantabria, 4. Basque Country, 5. Navarra, 6. La Rioja, 7. Aragón, 8. Catalonia, 9. Comunidad Valenciana, 10. Murcia, 11. Andalusia, 12. Extremadura, 13. Castilla-la Mancha, 14. Madrid, 15. Castilla-León.

The spatial intensity and the rapidity of recent changes in Spain offers a paradigmatic example of the fast shift toward a new system of urban–rural relationships in the Mediterranean basin, based on a modified dichotomy between urban and rural areas (Stellmes, Röder, Udelhoven, & Hill, 2013). A deep knowledge of the main spatial changes may enhance future management with the objective, for instance, to mitigate land degradation and fragmentation, depopulation, and the loss of natural resources and to re-balance excessive human pressures on coastal areas.

The aim of the present study is twofold: to provide a methodological framework for the diachronic analysis of land and socioeconomic spatial changes combining different types of data provided from statistical censuses, land-cover maps, and GIS data, and to analyse how the general trends of intensification and extensification (or abandonment) have shaped the traditional urban–rural dichotomy in Spain over the last 20 years at local (municipality) scale. The proposed framework may help in the identification of driving forces and socio-environmental consequences of the rapid regional dynamics observed in Spain in the last two decades (from early 1990s to early 2010s), taken as a paradigmatic example of the drastic landscape and socioeconomic transformations affecting the entire region. To our knowledge, the present study is the first at the Mediterranean scale to integrate socioeconomic and land-use variables in a unifying approach to the analysis of changes in urban–rural relationships at the local scale with a large coverage (e.g. national or supranational).

Study area

The present study concentrates on the Spanish Iberian Peninsula (SIP), located in the Western Mediterranean, and excludes the Balearic and Canary Islands (Fig. 1a). SIP has a total surface of 493,689 km^2, covering 15 autonomous communities (Fig. 1b), 47 provinces, and 8024 municipalities, which correspond to the NUTS-5 (Nomenclature of Territorial Units for Statistics) and represent the minimum mapping unit of most Spanish statistical surveys; municipal spatial units are also easily interpretable by policy-makers and other stakeholders interested in regional planning and urban–rural geography (Salvati et al., 2013) (Fig. 2). SIP population distribution is uneven: 47.4% of total municipalities have fewer than 500 inhabitants, in contrast with the Spanish capital, Madrid, concentrating 3.2 million, and other province capitals that range from 1.6 million residents in Barcelona to Teruel, the smallest capital, with 35,000 inhabitants. The SIP orography is very diverse, with important mountain ranges, valleys, and narrow straits historically contributing to the spatial distribution of human activities in the territory. Three main climatic types may be distinguished according to the geographical situation and topography characteristics. The Mediterranean climate is characterized by dry and warm summers and cool to mild and wet winters. The oceanic climate prevails from the Pyrenees to Asturias and is characterized by relatively mild winters and warm summers. Rainfalls are generally abundant, exceeding 1000 mm and are fairly spread out over the year. Finally, the semi-arid climate can be found in southeastern Spain and in certain parts of the Ebro Valley, with very hot summers and dry periods usually extending into the autumn (Del Río, Herrero, Fraile, & Penas, 2011).

From an economic point of view, one of the main characteristics of recent years was the rise of the "housing bubble": a drastic expansion of the construction industry pursuant to deregulation measures approved by central government that defined rustic land as potential construction sites, together with very permissive legislation for building and urbanizing during the second part of the 1990s (Albertos & Sánchez, 2014; Etxezarreta, Navarro, Ribera, & Soldevila, 2011). The consequence was that from 2004 to 2005 housing stock increased by 23 million units (Chislett, 2008). At the

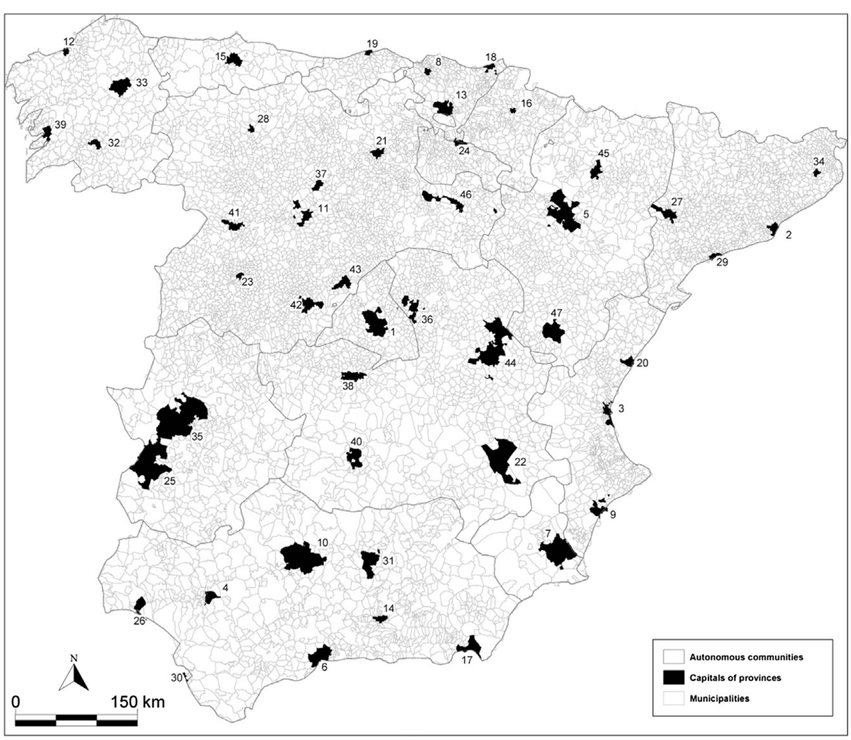

Fig. 2. Study area: Spain (Iberian Peninsula), showing capitals of provinces and administrative boundaries: 1. Madrid; 2. Barcelona; 3. Valencia; 4. Sevilla; 5. Zaragoza; 6. Málaga; 7. Murcia; 8. Bilbao; 9. Alicante; 10. Córdoba; 11. Valladolid; 12. A Coruña; 13. Vitoria-Gasteiz; 14. Granada; 15. Oviedo; 16. Pamplona-Iruña; 17. Almería; 18. Donostia; 19. Santander; 20. Castellón de la Plana; 21. Burgos; 22. Albacete; 23. Salamanca; 24. Logroño; 25. Badajoz; 26. Huelva; 27. Lleida; 28. León; 29. Tarragona; 30. Cádiz; 31. Jaén; 32. Orense; 33. Lugo; 34. Girona; 35. Cáceres; 36. Guadalajara; 37. Palencia; 38. Toledo; 39. Pontevedra; 40. Ciudad Real; 41. Zamora; 42. Ávila; 43. Segovia; 44. Cuenca; 45. Huesca; 46. Soria; 47. Teruel.

end of 2006, the extremely high price of houses slowed the building boom, and the resulting crisis in the construction sector has been aggravated by financial crisis since the second semester of 2007.

Methodology

Data description

With the objective to identify changes in the main demographic, socioeconomic, land-cover and geographical characteristics of the SIP over time (1991–2011), a total of 36 variables (Table 1) were included in the study. The selection of variables was based on previous studies and data availability in the three periods of time considered here (1991, 2001, and 2011) (Pallarès, Tulla, Badia, Serra, & Vera, 2003; Serra et al., 2013). Some socioeconomic variables were excluded because they were not available at the municipal scale, or the data were lacking for a particular period (for example, gross domestic product per capita was not available in 1991), or there was a high level of correlation between them (close to 1), as in the case of total population and public welfare installations (for instance, number of hospital beds).

Appendix 1 (supplementary materials) describes all the data sources; variables were mainly extracted from the Spanish Statistical Institute, from CORINE Land Cover maps (1990, 2000, and 2006) using GIS techniques, and from a digital elevation model (DEM) provided by the Cartographic Institute of Catalonia (ICC). The surface of all land-cover categories was quantified according to the area (in hectares) of each municipality, varying by the year analysed. In the case of geographic variables (corresponding to elevation, slope, and the first 20 km of distance to the Mediterranean coast and to mountain ski resorts), these were calculated using the same GIS methodology but yielded the same values for each year due to their invariable or constant nature.

Table 1
Variables and sources included in the analysis.

Variables	Code	Source	Measurement units
Number of farms	A1	Statistical censuses	Absolute number
Livestock units	A2	Statistical censuses	Absolute number
Agricultural area	A3	Statistical censuses	Hectares
Total population	B1	Statistical censuses	Absolute number
Young population (0–14 years)	B2	Statistical censuses	Percentage
Adult population (15–65 years)	B3	Statistical censuses	Percentage
Elder population (more than 65 years)	B4	Statistical censuses	Percentage
Dwellings (main residences)	B5	Statistical censuses	Absolute number
Secondary residences	B6	Statistical censuses	Absolute number
Unemployment	B7	Statistical censuses	Absolute number
Agricultural workers	B8	Statistical censuses	Percentage
Industrial workers	B9	Statistical censuses	Percentage
Construction workers	B10	Statistical censuses	Percentage
Service workers	B11	Statistical censuses	Percentage
Hotel supply	B12	Statistical censuses	Absolute number
Camping supply	B13	Statistical censuses	Absolute number
Non-irrigated arable land	C1	CORINE LC	Hectares
Irrigated arable land	C2	CORINE LC	Hectares
Bare soil	C3	CORINE LC	Hectares
Complex agro-forest patterns	C4	CORINE LC	Hectares
Forest	C5	CORINE LC	Hectares
Olive groves and vineyards	C6	CORINE LC	Hectares
Natural grasslands and pastures	C7	CORINE LC	Hectares
Fruit trees	C8	CORINE LC	Hectares
Green urban areas	C9	CORINE LC	Hectares
Continuous urban fabric	C10	CORINE LC	Hectares
Discontinuous urban fabric	C11	CORINE LC	Hectares
Altitude from 0 to 300 m	D1	Digital elevation model	Hectares
Altitude from 300 to 600 m	D2	Digital elevation model	Hectares
Altitude above 900 m	D3	Digital elevation model	Hectares
Slope from 12.1 to 25° and altitude from 600 to 900 m	D4	Digital elevation model	Hectares
Slope from 0 to 3°	D5	Digital elevation model	Hectares
Slope from 3.1 to 12°	D6	Digital elevation model	Hectares
Slope above 25°	D7	Digital elevation model	Hectares
Distance to Mediterranean coast (first 20 km)	D8	Spanish boundaries	Hectares
Distance to ski resorts (first 20 km)	D9	Diverse sources	Hectares

Statistical analysis

An exploratory multivariate data analysis was performed to identify latent relationships between variables over time and space at the municipal scale. Factor analysis (FA) looks for the nature of relationships between a large number of variables, 36 in our case, by defining a set of common underlying dimensions or factors. FA is a common tool employed in different fields, such as socio-ecological vulnerability (Abson, Dougill, & Stringer, 2012) or water consumption (Nosvelli & Musolesi, 2009), among others. Nevertheless, the present objective was to achieve a significant data reduction using principal component analysis (PCA) but including changes, avoiding a static temporal analysis. Two different tests were used to calculate the correlation of original variables: the Measure of Sampling Adequacy (MSA) and the Kaiser–Meyer–Olkin (KMO) (Norušis, 1994). The extraction of principal components (PC) was developed according to the eigenvalue criterion, usually greater than one (Hakstian, Rogers, & Cattell, 1982). The next indicator calculated was the proportion of variance among the original variables explained by the selected PC, known as communality, where values near 1 indicated that common factors retained the main information of original variables and near 0 indicated the opposite. The next step was to obtain the PC matrix that showed the weight of each retained PC in relation to each original variable, a value known as PC loading. The final matrix was rotated using the Varimax rotation to obtain loadings that would be easier to interpret and to calculate the final values for each PC and municipality using its score coefficients. Initially, only two municipalities were not included, Madrid and Barcelona, although their metropolitan areas were analysed, because of their large weight (in terms of both population and economic activities) compared with the rest of municipalities. Eventually, 125 additional municipalities were excluded (1.5% of total) due to incomplete data.

In order to avoid using incomparable factors obtained for each of the periods analysed, the method from Serra et al. (2013) was adopted. The process consists on calculating a complete PCA with the data from the first period of time analysed (1991), obtaining the corresponding tests (to know its robustness), PC loadings (to extract the weights of each PC versus each of the 36 original variables) and PC score coefficients (used to obtain the final values for each PC and municipality). After that, in order to analyse the two following periods of time (2001 and 2011) instead of calculating a new complete PCA for each of them (and to obtain new tests, PC loadings and score coefficients), the 1991 PC score coefficients were applied to the 36 standardized original variables for 2001 and for 2011, respectively. The resulting process was the extraction of the final values for each

PC, municipality, and period of time, providing fully comparable results because the changes in the final PC values were just due to the changes in the own variables of 2001 and 2011 and not attributable to the 1991 PC score coefficients because they were constant.

To summarize the analysis of changes and to avoid examining an excessive number of factors (eight for each period, 24 in total), the following step was to apply a non-hierarchical clustering method in order to group the municipalities with similar dynamics using a Euclidean distance. The final number of clusters retained was nine, used to identify and map the main spatial dynamics related to land intensification and extensification.

Results

Statistical results

PCA analysis for 1991 showed the following results: the MSA values for all the variables were above 0.5, the KMO value was 0.7, and all the communalities were also above 0.5. These results validated the application of FA because the original variables were sufficiently correlated to share common factors. Eight PC were retained, according to the eigenvalue criterion, with 71.6% of total variance explained. Table 2 shows the individual variance explained from each PC and its label based on loadings. After applying the PC score coefficients extracted in 1991 to the original variables of the following periods (2001 and 2011), the evolution of variance explained was 66.9% and 67.1%, respectively. The main dynamics reported were the increase of urbanization in 1991–2001 and 2001–2011; the increase in the last study period of herbaceous crops, tourism, forest, and fruit trees; and the decrease of livestock and pastures, mountain tourism, and young population. Fig. 3 shows the evolution of the eight PC according to the most important original variables shown in Table 2. In the urbanization PC, the decrease of industrial, construction and service workers and the increase of continuous urban fabric is evident from 1991 to 2011, whereas in the livestock and pastures PC there is a generalized decrease in all the variables, with the exception of livestock units (A2) (Fig. 3a). Fig. 3b illustrates the maintenance of herbaceous crops PC and the decrease in all the variables from 1991 to 2001 and the increase from 2001 to 2011 of the tourism PC. This process is related to the economic crisis in the early 1990s, which affected domestic tourism, and the eventual recovery (Pellejero, 2005). In the case of mountain tourism PC and forest PC Fig. 3c shows the stable behaviour of variables, whereas Fig. 3d exemplifies the decrease of youth population PC and the maintenance of fruit trees PC.

Identifying processes contributing to the change in urban–rural relationship

The processes of change are summarized in Table 3, showing the cluster analysis results after labelling according to the highest values. According to these results, the main spatial dynamics

Table 2
Evolution of the variance explained by principal components (PC).

PC number	PC name	High PC loadings > 0.5	Code	Variance explained (%)				
		Original variables		1991	2001	2011	Variation 1991–2001	Variation 2001–2011
1	Urbanization	Total population	B1	21.6	22.1	22.4	0.5	0.3
		Adult population	B3					
		Dwellings	B5					
		Unemployment	B7					
		Industrial workers	B9					
		Construction workers	B10					
		Service workers	B11					
		Continuous urban fabric	C10					
2	Livestock and pastures	Livestock units	A2	9.4	9.4	7.9	0	−1.5
		Agricultural area	A3					
		Complex agro-forest patterns	C4					
		Pastures	C7					
		Altitude 300–600	D2					
		Slope 3.1–12.0	D6					
3	Herbaceous crops	Agricultural area	A3	8.5	8.2	8.5	−0.3	0.3
		Non-irrigated arable land	C1					
		Irrigated arable land	C2					
		Altitude 0–300	D1					
		Slope 0–3	D5					
4	Tourism and second home urbanization	Secondary residences	B6	7.1	4.4	6.5	−2.7	2.1
		Hotel supply	B12					
		Camping supply	B13					
		Green urban areas	C9					
		Discontinuous urban fabric	C11					
5	Forest	Forest area	C5	6.7	6.4	6.9	−0.3	0.5
		Altitude > 900	D3					
		Altitude 600–900 and slope 12.1–25	D4					
		Slope 3.1–12.0	D6					
6	Mountain areas with tourism	Bare soil	C3	6.5	6.5	6.3	0	−0.2
		Slope > 25	D7					
		First 20 km to ski resorts	D9					
7	Youth population	Young population	B2	6	4.3	2.5	−1.7	−1.8
		Elder population*	B4					
		Agricultural workers*	B8					
8	Fruit trees	Number of farms	A1	5.8	5.8	5.9	0	0.1
		Fruit trees	C8					
		First 20 km to Mediterranean coast	D8					
Total variance explained				71.6	66.9	67.1	−4.7	0.2

All variables with positive scores except for * with negative scores.

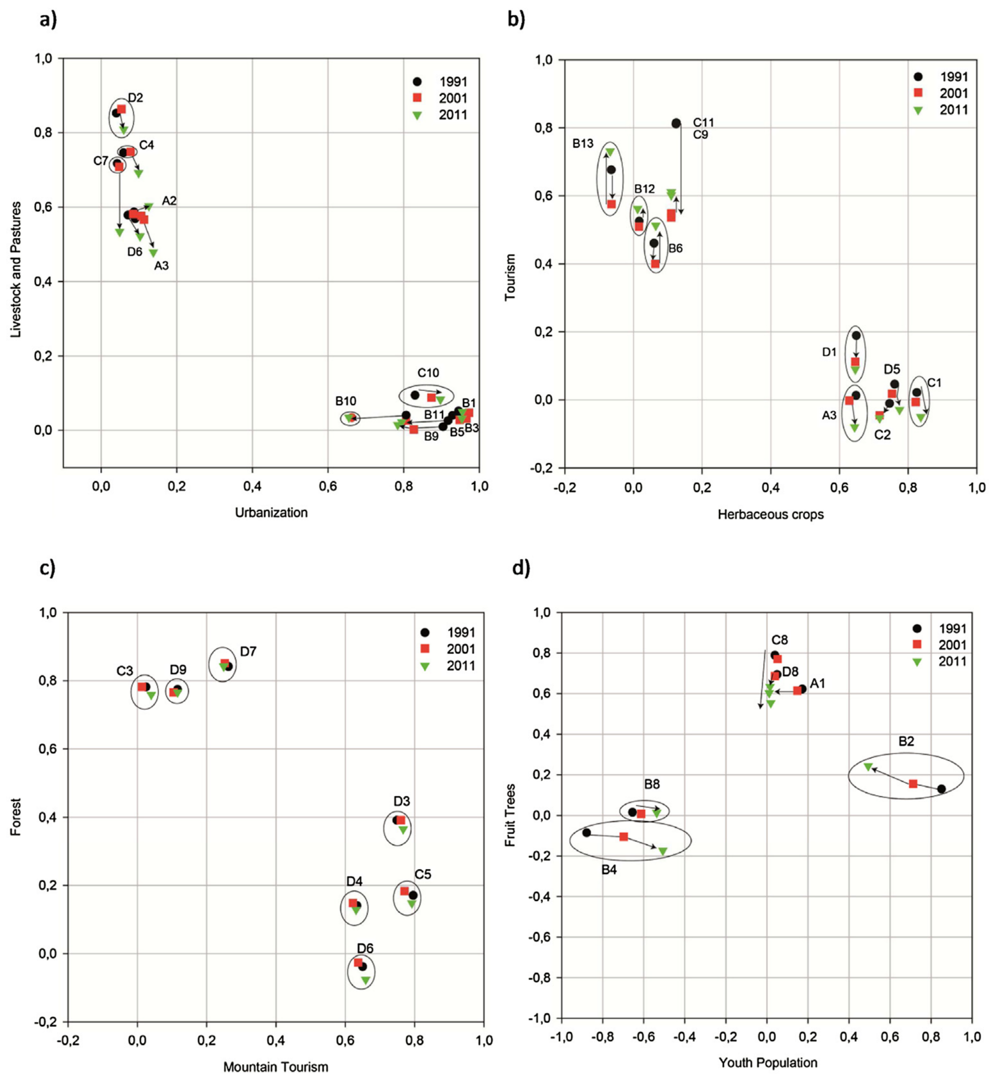

Fig. 3. Dynamics of the most important original variables related to the first eight principal components (PC). Code of variables according to Table 2.

related to intensification and extensification were identified and mapped.

Urban intensification

The municipalities with the highest values associated with urban intensification were located in and around some capitals of provinces, as shown in Fig. 4a. Of the 39 municipalities, 19 were capitals of provinces (Fig. 2), reflecting a process of urban intensification, and the rest to other cities, showing a process of urban sprawl mainly affecting Barcelona, Madrid, and the coast of Cantabria and Galicia. These results are consistent with other research. Catalán et al. (2008) studied the Barcelona Metropolitan Area, where the scattered occupation occurs in municipalities on the peripheral fringes of Barcelona city, mainly concentrating detached houses. In the Madrid Metropolitan Area, García-Palomares (2010) analysed the problems associated with the excessive use of private cars, producing an unsustainable mobility model. Another example of urban intensification work is the research on the coast of Alicante by Olcina, Hernández, Rico, and Martínez (2010); the authors assert an increased flood risk because of urban expansion into consolidated towns and new residential areas in that coastal region.

From our results, it is also clearly evident that urban intensification and sprawl was very weak or nonexistent around the most important cities of Castilla la Mancha, Extremadura, and Aragón. These results are consistent with the historical Spanish distribution of population. According to Ayuda et al. (2010), the population concentration in some provinces is due to the pre-industrial process, where natural factors — climatology, topography and market accessibility — determined the spatial location of populations, and the trends were reinforced by industrialization. Together with specific points of interest (tourist sites or important industrial areas, among others), the nature of Spain's transport network could exacerbate this situation. because the main distinguishing characteristic of road and rail infrastructures is the polarization around the capital city, Madrid, as a result of long-term policy based on a vision of a 'radial state' (Bel, 2011).

This scenario is complemented by those municipalities with a higher presence of young people and greater dynamism. Seven big groups, including 3120 municipalities, concentrated this process in eastern Catalonia, eastern Comunidad Valenciana, south-eastern Andalusia, central Extremadura, around Madrid, around Cantabria-Basque Country and Navarra, and in western Galicia (Fig. 4b).

Coastalization

The municipalities with coastalization intensification related to tourism are clearly visible around the Mediterranean coast of

Table 3
Results of cluster analysis.

	Cluster								
	Urbanization intensification and urban sprawl				Crop intensification		Extensification		Depopulation
	Urbanization intensification	Young population structure	Coastalization	Naturbanization	Herbaceous crops	Irrigated fruit trees	Livestock and pastures	Forest expansion	
Number of municipalities	39	3120	109	67	281	34	215	431	3457
1991									
Urbanization	8.86	−.04	0.04	−0.02	.00	1.22	−.09	−.08	−.10
Pastures	−0.21	−.13	−0.16	0.42	.08	0.70	3.29	−.10	−.15
Herbaceous crops	−0.91	−.17	−0.47	−0.12	1.95	1.50	−.27	−.06	−.05
Tourism	−0.20	−.08	6.11	0.19	−.32	0.28	−.09	−.09	−.08
Forest	0.20	−.23	−0.30	1.09	−.48	0.46	−.14	2.25	−.12
Mountain tourism	−0.29	−.07	−0.05	8.31	.03	−0.14	−.26	.25	−.10
Youth	0.67	.77	0.60	0.14	.50	0.12	.08	−.12	−.77
Fruit trees	−1.63	.04	0.39	−0.15	.04	9.98	.06	−.04	−.11
2001									
Urbanization	8.96	−.03	0.63	−0.07	.03	1.83	−.10	−.12	−.13
Pastures	−0.27	−.14	−0.20	0.40	.12	0.71	3.28	−.10	−.14
Herbaceous crops	−0.93	−.18	−0.49	−0.12	1.93	1.42	−.29	−.05	−.04
Tourism	0.11	−.12	3.89	0.62	−.32	−0.02	−.04	.08	−.01
Forest	0.33	−.23	−0.43	0.97	−.50	−0.12	−.12	2.27	−.11
Mountain tourism	−0.39	−.07	0.11	8.41	.02	0.03	−.25	.25	−.11
Youth	0.41	.86	0.53	0.05	.43	−0.07	.06	−.07	−.84
Fruit trees	−1.81	.03	0.55	−0.27	.09	9.91	.04	−.09	−.11
2011									
Urbanization	7.51	−.02	0.60	−0.09	.06	2.35	−.10	−.12	−.13
Pastures	0.01	−.08	−0.16	0.39	.11	0.82	2.75	−.22	−.13
Herbaceous crops	−0.70	−.17	−0.55	−0.11	1.93	1.48	−.22	.00	−.06
Tourism	1.52	−.11	4.53	0.33	−.32	0.10	−.10	−.04	.00
Forest	−0.13	−.30	−0.73	1.18	−.52	0.36	.01	2.31	−.05
Mountain tourism	−0.13	−.03	0.34	8.28	.00	−0.08	−.45	.19	−.12
Youth	−0.20	.69	0.01	0.20	.15	−0.09	−.21	−.06	−.60
Fruit trees	−1.79	.01	0.44	−0.28	.18	7.46	.30	−.07	−.19

Rows in grey are the maximum values, positive or negative.

Catalonia, Valencia, and Andalusia (Fig. 4c). From 106 municipalities involved in such a process, there were three exceptions: Madrid and surroundings (10 municipalities), the Cantabrian coast (five municipalities), and the Galician coast (13 municipalities). The process of coastalization is mainly due to the Spanish tourism model based on sun and sand and mass tourism (Aguiló, Alegre, & Sard, 2005), evidenced by the appearance of accessibility infrastructures and belts of building construction along the coast, usually in the form of private "urbanisations". Examples of such evolution are the *Costa Brava* and *Costa Daurada* in Catalonia, the *Costa Blanca* in Alicante, or the *Costa del Sol* in Andalusia. Perhaps, one of the most emblematic examples of coastal artificialization is Benidorm, located in the *Costa Blanca*, because it concentrates high population densities (more than 140 hotels and more than 30,000 tourist beds) and vertical growth. This model of tourism has been much criticized for being environmentally destructive and more vulnerable to certain hazards such as floods, and for producing marginalization and depopulation of the coastal hinterland (Rico-Amoros, Olcina-Cantos, & Saurí, 2009).

An additional factor of coastal attraction is golf tourism, which includes various forms of residences and of property development that in most cases can be associated with land speculation. As Priestley asserts (2006), the best-known golf regions in southern Europe are the Spanish Andalusian coast from Malaga west to the border of Portugal. In fact, nowadays the 12 Spanish Mediterranean coastal provinces contain 53.5% of Spain's total golf camps (source: www.territoriogolf.com). The process of coastal artificialization described in this study is consistent with that described by Pons and Rullan (2014), where coastalization is visible all around the European Western Mediterranean, from Spain to Italy.

Naturbanization

The most important areas associated with naturbanization corresponded to the Pyrenees (34 municipalities) and the Cantabrian range (28 municipalities), where there is a major presence of ski resorts combined with protected areas (natural parks) (Fig. 4c). These results align with the analysis developed by Barrachina (2009) in the Catalan Pyrenees, where a progressive implementation of tourist facilities and establishments has grown due to the efforts of major naturbanization actors: land owners (usually ageing farmers who prefer to sell), town councils with an interest in all the economic potential, and land buyers and promoters. In this sense, and according to Collantes and Pinilla (2004), the tourism model based on recreational exploitation of winter sports has been more successfully implemented in the Pyrenees than in the Iberian System.

Another example of naturbanization is the work by Entrena (2005) that analyses two Andalusian city-regions, one located around Granada city and near the Natural Park of Sierra Nevada and its associated ski resort. The case of Güejar Sierra municipality totally coincides with our results (Fig. 4c): natural environments and landscapes of Sierra Nevada attract population in search of second homes and employment. On the other hand, naturbanization has been also analysed in other European regions such as in Northern Portugal, near the Peneda-Gerês National Park (Lourenço, Quental, & Barros, 2009).

Crop intensification

Fig. 4d shows the crop herbaceous intensification around the Ebro, Duero, Tajo, and Guadalquivir river basins with a total of 281 municipalities involved. According to this figure, the high importance of irrigation is visible as a result of consolidation and new implementations. In fact, in Spain, the introduction of irrigation as a

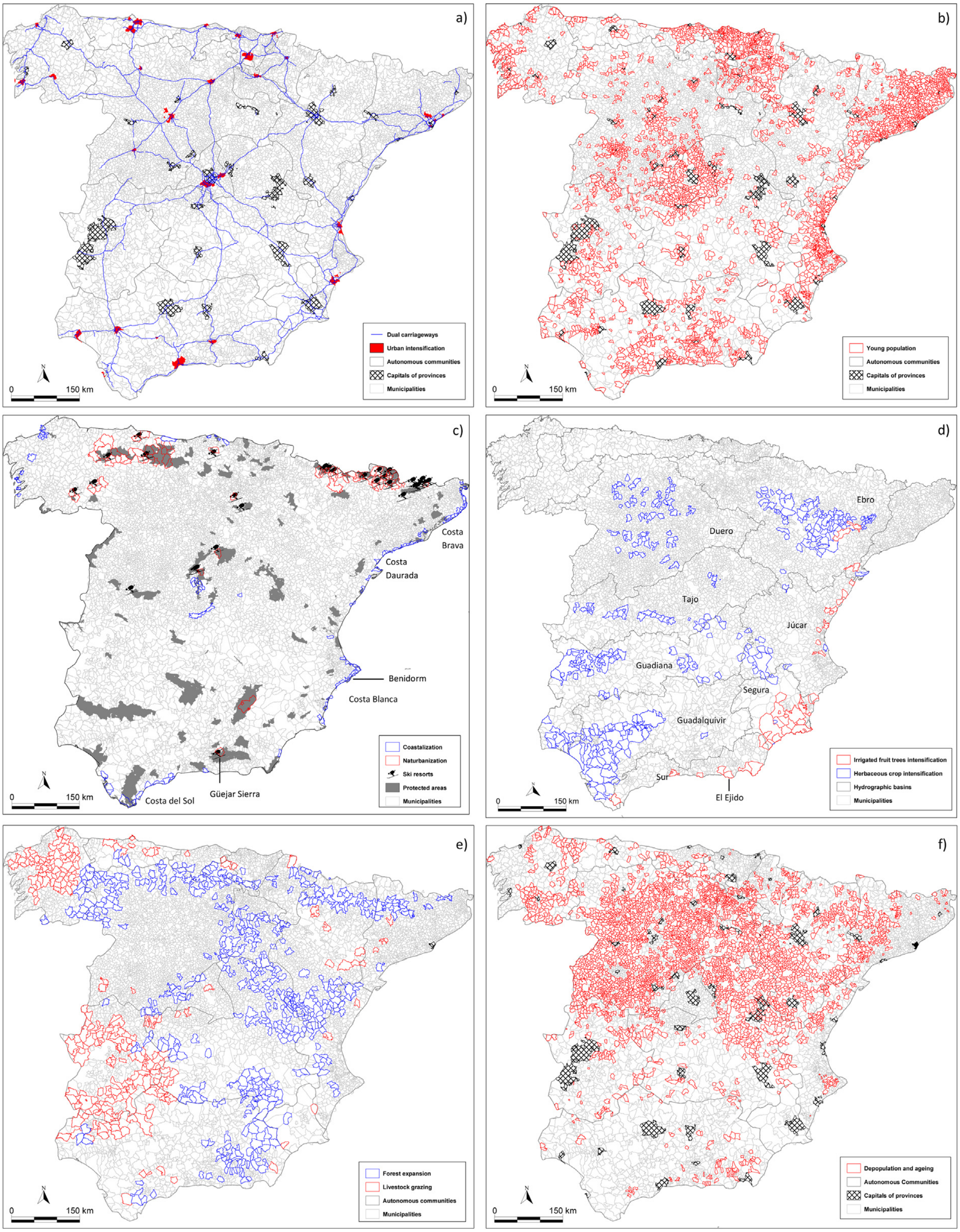

Fig. 4. a) Urban intensification and urban sprawl around metropolitan areas and capitals of provinces; b) Young people distribution. c) Coastalization as tourism intensification and naturbanization as a consequence of mountain tourism intensification; d) Irrigated agriculture intensification. e) Livestock and pastures and afforestation extensification; f) Depopulated and aged municipalities.

tool to sustain rural population has persisted over time, at least in the inland regions of the country (Silvestre & Clar, 2010), because irrigation land may generate up to 50 times more direct employment than non-irrigated land (Grindlay, Lizárraga, Rodríguez, & Molero, 2011). Our results are consistent with Rodríguez, Weatherhead, Knox, and Camacho (2007), a study of the growth of the irrigated surface in the Guadalquivir river basin. In the case of the Ebro basin, the increase corresponded to some irrigation districts, mainly the Aragon-Catalonia Canal, where the work from Silvestre and Clar (2010) concluded that an increase in population density was clearly detected.

Fig. 4d also shows the municipalities highly weighted with irrigated crops, being probably the most paradigmatic case El Ejido municipality, on the southeast coast of Andalusia. In the beginning of the 1960s, this was an area of dispersed housing in a poor rural area. At the turn of the century it was converted into an enormous “plastic sea” of greenhouses to cultivate fruits and vegetables for international export (Entrena, 2005). Other areas with herbaceous intensification were Murcia, north-east of Valencia and west of Catalonia. In the case of Murcia, farms are supplied by surface water coming from the Tajo-Segura transfer (given the water scarcity in the Segura basin), groundwater and reclaimed water. As a result of this intensive irrigated agriculture, some urban sprawl has been observed around the main cities of the coast: Murcia (the capital), Cartagena and Lorca (Grindlay Zamorano, Rodríguez, Molero, & Urrea, 2011). Finally, taking into account that one third of European orchards are located in Spain, the main intensification of irrigated fruit trees were visible in Comunidad Valenciana, mainly oranges and small citrus (34 municipalities); Murcia (apricot and lemon trees); La Rioja (pears); Aragon and Catalonia (peaches and pears); and Galicia and Catalonia (apples).

Livestock and pastures extensification

The process of livestock grazing extensification (with 215 municipalities involved in total) mainly occurred around Extremadura, as an example of Mediterranean pastures (known as *dehesas*), and Galicia, as an example of Atlantic pastures (Fig. 4e). A *dehesa* is an agro-silvo-pastoral system of extensive utilisation characterized by the presence of an open tree layer, mainly dominated by Mediterranean evergreen oaks and to a lesser extent by deciduous oaks, ashes, and wild olives. They are used for extensive livestock operations (sheep, cattle, and pigs) and cereal cultivation in long rotations (Cañellas, Roig, Poblaciones, Gea-Izquierdo, & Olea, 2007). The *dehesa* system dominates the landscape of the south-western provinces of Spain (Salamanca, Extremadura and Western Andalusia) and the southern provinces of Portugal (Alentejo). According to Gaspar, Mesías, Escribano, Rodríguez, and Pulido (2007), the most profitable farms either have high overall livestock density or a high level of Iberian pig production, due to the high economic value of cured Iberico ham.

In the case of Galicia, the establishment of silvopastoral systems has increased in recent years because they offer some benefits to farmers, such as grazing for livestock production, diversification of production, and a tool for fire prevention (Lasanta, Arnáez, Errea, Ortigosa, & Ruiz-Flaño, 2009). According to Mosquera, Fernández, and Rigueiro-Rodríguez (2006), this latter benefit is particularly important in Galicia because it replaces easily inflammable shrubs with herbaceous cover of higher nutritional value and low flammability, and helps to slow rural abandonment.

Forest expansion and depopulation

The SIP forest expansion (with 431 municipalities in total), as a result of agricultural abandonment and forest replantations, is clearly visible as an inland process located in the Meseta plateau and in more isolated mountainous areas without a naturbanization presence (Fig. 4f). Since 1950, agricultural decline and abandonment has been widespread in many rural areas of Europe, especially in areas less favoured from a socioeconomic point of view. For example, Serra, Pons, and Saurí (2008) analysed land-use changes in a Spanish Mediterranean region, concluding that in transitional areas (with an altitude from 100 to 400 m) abandonment, mainly of permanent crops (vineyards and olive trees), was located in parcels with steep slopes where mechanization was difficult and fields were fragmented. Similar results were reported by Sluiter and de Jong (2007) in an area at the fringe of the French Massif Central and by Zomeni, Tzanopoulos, and Pantis (2008) in northwestern Greece, where a decrease of cropland in mountain villages and agricultural modernization in lowlands were detected.

According to our results, the most depopulated and aged municipalities (3457 municipalities in total) were located in the north of the Meseta plateau and in the following autonomous communities: Castilla y León, La Rioja, northeastern Castilla-La Mancha, northern Extremadura, southwestern Aragón, inland areas of Catalonia and southern Galicia (Fig. 4f). All the municipalities included were mainly characterized by the predominance of agricultural workers, a reduced number of inhabitants, and a predominantly elderly population. As mentioned before, this situation is a consequence of the historical spatial distribution of population, among other factors. For example, Collantes and Pinilla (2004) analysed the extreme depopulation in some rural mountain areas of the Autonomous Community of Aragón, where the population density was a sparse 5.6 inhabitants per km^2. One of the most important reasons for this situation is the poor transport infrastructure (Fig. 4a) and services endowment compared with other Spanish mountain areas. In the case of Castilla y León, Martínez & Delgado (2013) assert than in the 1950s the population was bigger and had a more uniform spatial distribution. Over the next decades, after some emigration processes, the capitals of provinces and the older industrial cities such as Miranda de Ebro or Aranda de Duero were gradually concentrating the regional population (Fig. 4b). At the same time, the rest of municipalities with a deep rural component were reducing their population, arriving at a complete demographic standstill.

The dry cereal-steppe farming system characteristic of the Meseta of Central Spain, with its slightly undulating topography, open spaces, and the Mediterranean continental climate, is associated with depopulation (Oñate, Atance, Bardají, & Llusia, 2007). The main feature is its low-intensity arable system that includes a crop rotation of winter cereals (mainly barley and wheat), fallow land and legumes (lucerne or vetch), and sheep grazing on the stubble of crops and enhancing the organic content of the soil with dung (Caballero, 2001). In fact, the agricultural productivity in Castilla y León is low compared with the whole European Union, with farm production highly dependent on Community Agricultural Policy (CAP) subsidies (Gómez-Limón, Gómez-Ramos, & Sánchez, 2008).

Discussion

From a methodological point of view, the main advantages of our method are quickness and consistency. The former advantage is achieved because the same 36 variables from an older or a newer period of time can be used to obtain the corresponding PC values just using the 1991 score coefficients, avoiding calculating new PCA. As reported in Serra et al. (2013), when the objective is to analyse changes the comparison using different PCA may complicate the interpretation of results because the number of main PC and their loadings can change from one period to another (as happened when we tried this option) and the comparison becomes meaningless. The latter advantage becomes successful because using exactly the same variables the results are fully comparable as the changes in the outcomes are due exclusively to the modifications in the values of the original variables. However, this requirement can be the main drawback of the method because sometimes it is difficult to have data for a variable with a long perspective; this fact can be worse since sometimes in the censuses the methodological conditions to calculate a variable can change. This situation can reduce the number of variables to be included in the analysis, producing a decline in the richness of the results.

Another important requirement to be considered is that PCA has sense when a large number of variables are used, being the different tests (MSA, communalities, and KMO) the main indicators to validate it; for instance MSA and KMO values below 0.5 and 0.6, respectively, invalidate the PCA. In this sense, we suggest trying to include as many variables as possible but excluding those with an excessive correlation among them, as reported in the data description section, because the resulting PC could be poor. This fact can be clearly detected according to the variance explained by each PC and the total variance explained by the retained PC. On the other hand, in change analysis the evolution of the variance explained can change; for instance, our work has shown a small variance decline, from 71.6% in 1991 to 67.1 in 2011, as a sign that the retained PC were a few less explicative of the original data, as reported in Table 2 and Fig. 3.

According to the results, from a planning point of view our study is an alternative or complement to the works that analyse changes extracted from aerial photographs and/or remote sensing images that produce raster maps. The advantages of our method consist in the inclusion of different sources (socioeconomic data and land-use information) and in the results at municipality scale, more useful for planning purposes because it is a real scale of management. Finally, the high number of cases (nearly 8000) has given a high robustness to the applied method.

Conclusions

An exploratory data analysis was successfully applied to data from different statistical sources to analyse spatial dynamics in Spain during the last 20 years, differentiating three periods of time (1991, 2001 and 2011) with contrasting socioeconomic characteristics. Eight PC were extracted from the 36 selected variables explaining 771.6% of total variance. After applying the factor score coefficients from the 1990s to the 2001 and 2011 data, making the results fully comparable, a change detection analysis was developed using a non-hierarchical clustering technique to summarize the 24 PC (eight for each period) and group about 8000 municipalities with the same dynamics into nine clusters.

The study identifies the most important processes of intensification and extensification observed during the last 20 years: (i) urban intensification and sprawl, (ii) coastalization, (iii) naturbanization, (iv) crop irrigated intensification, (v) livestock and pasture extensification, (vi) afforestation and reforestation due to agricultural abandonment, and (vii) depopulation. Urban sprawl has been detected around main Spanish metropolitan regions, and an increase in tourism and second residences also has been mapped due to coastalization (especially in the Mediterranean coast) and naturbanization (in mountain areas near to natural parks and ski resorts). All these processes consolidate the dichotomy between the coast and metropolitan regions, with economic activities and the dynamism associated with a young population, versus some municipalities located in the SIP interior, where depopulation and an aged population is the main trajectory. Our results clearly identified this dualistic situation, which has deep historical roots, during the recent period analysed.

Although some of these processes have been partially analysed in previous studies and many different countries (urban sprawl, naturbanization, etc.), this paper aimed to give a panoramic view of spatial changes at local scale using statistical and cartographic techniques. The analysis illustrates how spatial changes may be a target for national, regional, and local policies to mitigate their more undesirable consequences, including landscape degradation, population concentration in coastal areas, or depopulation. Finally, the methodology applied in this work may be useful to investigators studying spatial dynamics in other regions and countries around the world.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.apgeog.2014.09.005.

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