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A minimum indicator set for assessing resources quality and environmental impacts at planning level in a representative area of the European Mediterranean Region

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ABSTRACT

According to some European Institutions (European Environment Agency, Commission of the European Communities), Environmental Impact Assessment (EIA) could be a better tool to assist natural resource protection in the context of land use planning than when used only for assessing specific projects. Environmental assessment of planning instruments allows the comparison of different alternatives and to scope the analysis and evaluation of relevant impacts when developing projects in the alternatives selected. This paper develops a minimum indicator set useful to evaluate natural resources quality at municipality level as a basis for assessing environmental impacts derived from land use planning instruments and from specific projects in the Valencian region, a representative area of the European Mediterranean Region. Using Principal Component Analysis (PCA), a minimum set of 12 indicators which referred to relevant natural resources (air, water, soil and biodiversity) was defined and used to assess the resources quality of different municipalities of the Valencian region, following a value-function based approach. The results obtained were very similar to those obtained in another study done in the same area that applied a broader set of indicators. These results and the potential reduction in costs estimated show the usefulness of the minimum set of indicators defined in this work for evaluating resources quality. As a demonstration exercise, the indicator set was applied to three municipalities representative of the different land use conflicts and environmental problems of the Valencian region, in order to assess the environmental impacts on natural resources that could be produced from the implementation of a hypothetic urban-industrial expansion plan, a usual land use pattern that has occurred in the European Mediterranean Region in the lasts decades. The results obtained show that coastal municipalities are better alternatives to implement an urban-industrial expansion than inland and intermediate municipalities in terms of environmental impacts although the loss of high productivity soils must be avoided. Given that the environmental issues considered are representative of the European Mediterranean Region, it follows that the approach developed in this work can be useful to predict environmental impacts on natural resources from planning instruments in the whole region.

1. Introduction

The Environmental Impact Assessment (EIA) European Directives (DOCE, 1985, 1997, 2001, 2012) state the projects and plans for which environmental impacts have to be assessed in the European Union. The adoption of these Directives by the Member States of the European Union has resulted in the inclusion of EIA in their National legislation. Within some Member states (e.g. Spain), Regional Governments (e.g. Generalitat Valenciana) have also established EIA legislation for specific plans and projects that are relevant at regional level (DOGV, 1989, 1990, 2005, 2006), adapting the legislation to the particularities of each region.

Different methods have been proposed in order to carry out Environmental Impact Assessment since the implementation of this tool in the seventies (e.g. Leopold et al., 1971; Odum, 1972; Odum and Odum, 1976; Whitman et al., 1973). Indicator-based methodologies are one of the most important approaches used in EIA (Petrosillo et al., 2012) since they reduce the volume and complexity of information (Benini et al., 2010) that is required by stakeholders and decision makers (Donnelly et al., 2007).

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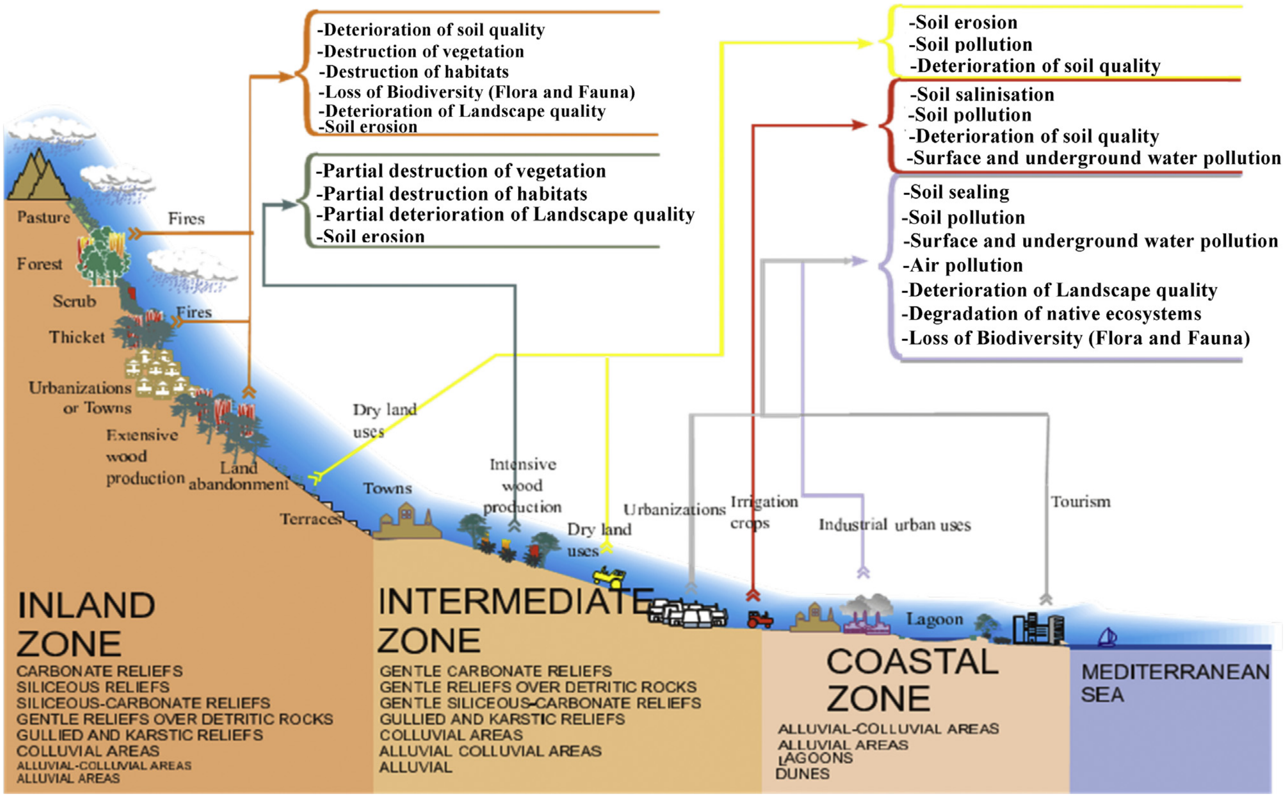

Fig. 1. Scheme showing the land use conflicts and environmental problems characterising the inland, intermediate and coastal zone of the Valencian Mediterranean region (after Recatalá et al., 2000; Recatalá, 2009).

Furthermore, the application of indicators and the corresponding value functions allows assessing the quality of the different resources affected by a planning instrument or by a project in the same dimensionless unit (resources quality units), enabling this way to integrate different quality values and to assess global environmental impacts, in order to compare alternatives.

However, the use of indicators has some drawbacks. Firstly, many sets of indicators are developed to address specific environmental issues, following different procedures and for different spatial scales (regional, national, international), making it difficult to define a core set of environmental indicators that can be used extensively (Donnelly et al., 2007). Several International Agencies (European Environment Agency, Commission of the European Communities) have tried to develop a core set of indicators but when analysing these sets in detail, substantial overlaps between the information provided by different indicators can be found. This is another of the drawbacks identified when defining and using environmental indicators. According to Yu et al. (1998), most of the sets of environmental indicators developed to evaluate the quality of the natural resources are redundant. This makes it difficult to analyse and interpret the information collected, since having redundant information can increase background noise. Furthermore, it generates an avoidable cost overrun when acquiring information. Therefore, when developing a set of environmental indicators, it is important to analyse the underlying effective dimensionality between them, in order to finally select a non-correlated group of indicators.

The aim of this paper is to develop a minimum indicator set useful to evaluate natural resources quality at municipality level as a basis for assessing environmental impacts derived from land use planning instruments and from projects in the Valencian region, a representative area of the European Mediterranean Region. Municipalities are the basic planning units where primary decisions on natural resources use are made in the Valencian region, as well as in Spain and in the European Mediterranean Region. Specifically, the minimum set of indicators was defined by applying Principal Components Analysis (PCA) to an initial set of indicators.

In order to show the relevance in economic terms of the minimum indicator set developed with respect to the initial set, an estimation of the potential reduction in costs was carried out.

As an example of the application at planning level of the set of indicators defined, this was applied to three municipalities representative of the different land use conflicts and associated environmental problems of the region (Fig. 1) (Recatalá et al., 2000; Recatalá, 2009), in order to assess the environmental impacts on natural resources derived from the implementation of a hypothetic land use planning instrument (a plan). Specifically, the situation referred to an urban-industrial expansion, a usual land use pattern that has occurred in the Valencian region and in the European Mediterranean Region in the last decades. For this demonstration exercise, in each municipality it was considered an increase of the land devoted to these uses equal to the mean occurred in the Valencian region for the last decades (from the nineties onwards), which has been of a 50%, one of the most intensive in Spain and even in Europe (OSE, 2007; Salom, 2010). This demonstration exercise was focused on environmental impacts referred to soil and biodiversity rather than to air and water, since these latter can be more properly assessed at project level because the type and amount of residues generated and released to the environment is specific for each activity projected (e.g. ceramic industry, car factory, metal industry, etc.).

2. Materials and methods

According to Recatalá (2009), the procedure to select an appropriate set of environmental indicators (Fig. 2) must include, firstly,

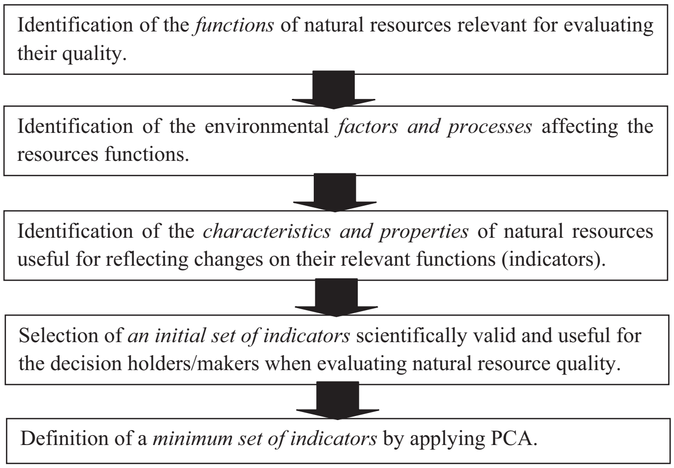

Fig. 2. Procedure to create an appropriate minimum set of indicators for evaluating natural resources quality and environmental impacts (Recatalá, 2009).

the identification of relevant natural resources that can be affected by land use plans, programmes and projects in the study area. The selection of these resources, which refer to air, soil, water and biodiversity, was done after consulting the current EIA legislation at European, national and regional level (e.g. DOCE, 1985, 1997, 2001, 2012; BOE, 1986, 1988, 2000, 2001, 2006, 2008, 2010, 2013a; DOGV, 1989, 1990, 2005, 2006), and doing a thorough bibliographical research (e.g. Marchini et al., 2009; McBride et al., 2011; Purvis et al., 2009; Tang et al., 2009; Zaharia and Murarasu, 2009).

Secondly, a set of relevant properties and characteristics of each of the resources selected, capable of indicating any change in the quality of them, was identified and selected. In order to create an easily updatable database, the most recent and accessible information of each resource at municipality level in the Valencian Mediterranean region was consulted in municipalities having own entity (BOE, 2013b). Specifically, the information identified and consulted was:

- The database corresponding to the air quality controls done by the Valencian Network of Atmospheric Contamination Control and Monitoring (CMAUH, 2009);
- The database corresponding to controls on the quality of the superficial water of the Valencian region (CHJ, 2008);
- The database developed at Centro de Investigaciones sobre Desertificación – CIDE by Sánchez et al. (2007) and Recatalá (2009), containing characteristics and properties of soils.
- The database on biodiversity generated by the Conselleria de Medi Ambient, Aigua, Urbanisme i Habitatge (Generalitat Valenciana) belonging to the Regional Government of Valencia (http://bdb.cma.gva.es/).

After having created the initial set of indicators from this information, Principal Components Analysis (PCA) was applied. PCA is a widespread mathematical technique (e.g. Masto et al., 2008; Qi et al., 2009; Yu et al., 1998; Zhu et al., 2008) that allows identifying a set of new variables or indicators (denominated Principal Components – PC) from an initial, broad set of variables. These new variables are independent; that means that the variance of the studied resource or system explained by one of the variables is not explained by any other variable of the new set. Therefore, this technique allows identifying the underlying dimensionality of the variables initially considered.

The database used in this study is shown in Table 1. The initial set of variables was selected considering it covered the main functions of the resources selected, needed to assess their quality (Recatalá et al., 2009a). Thus, the initial set of indicators finally selected were: (1) for air: NO_2 and O_3, since according to several authors NO_2 can be considered an indicator of the quality of air in urban areas and O_3 in rural areas (Calatayud et al., 2007; Sanz et al., 2007); (2) for water: Organic C, DQO, Conductivity, O_2 dissolved, Nitrates, Total Coliform and Cu. This set of indicators include the most important ones when evaluating the quality of water, according to the Confederación Hidrográfica del Júcar (CHJ, 2008); (3) for Soil: Soil sealed, Irrigated land area, Area of protected territory, Area occupied by natural vegetation[1] and Area affected by fires. Due to the fact that soil is a multifunctional resource and that different soil properties and characteristics can have different importance in terms of quality depending on what function is being considered (Doran and Parkin, 1994), the indicators selected are not specific physic-chemical properties but spatial characteristics that allow reflecting different functions of soil, that in this case were productivity and ecological functions. Soil sealed and Area affected by fires represented the lowest quality for soil when considering the productivity and ecological function, respectively; Irrigated land area represented the highest quality when considering the productivity function and Area of protected territory and Area occupied by natural vegetation represented the highest quality when considering the ecological function of soil. These indicators seem to be the most adequate to evaluate the quality of the resource soil at regional scale, considering the fact that similar criteria were followed in other studies, like the development of the Geoscientific Map of the Valencian region published by Diputación Provincial de Valencia, Universitat de València and Universidad de Cantabria (1986); (4) for Biodiversity: Near threatened species of flora, Near threatened species of fauna, Vulnerable species of fauna and critically endangered species of fauna. This set of indicators enables differentiating properly both of the components associated to biodiversity, flora and fauna.

Environmental data were not complete for all municipalities considered. In fact, from a total of 152 municipalities, it was possible to complete the database for 44. Thus, the database contained 44 municipalities and 18 initial indicators. Although the requirement in PCA to provide a relevant solution that states that the observation-to-variable ratio for this analysis has to be three to one (Grossman et al., 1991) could not be satisfied, according to Yu et al. (1998) a reasonable relevant solution could be achieved considering several aspects. Firstly, the ratio (44:18) exceeded two to one; secondly, the most relevant indicators for assessing resources quality were selected (as specified above); and finally, the database included municipalities belonging to each of the three zones (coastal, intermediate and inland zone) identified in the Valencian region, and are representative of the different land use conflicts and associated environmental problems of the Valencian and the European Mediterranean Region (Fig. 1).

Data for each of the resources considered were checked for normality using the Kolmogorov–Smirnov test. When necessary, data were transformed into a log normal distribution using an appropriate transformation function. After this, PCA was applied to the database generated. All the mathematical and statistical analysis was conducted using SPSS© version 15.

More details on the application of this procedure can be found in Sacristán (2009).

After having applied PCA, and selected the minimum indicator set, the resources quality of the municipalities was assessed using a value function based approach (e.g. Karlen et al., 1994). This kind of approaches implies the following operations: transformation,

[1] Although the term natural vegetation cannot strictly be applied to the Mediterranean environment; it refers here to areas having slightly disturbed vegetation other than crops and agricultural lands that have been abandoned.

Table 1
Initial set of environmental indicators for assessing natural resources quality at municipality level.

Municipalities	Air		Water						
	[] NO_2 $\mu g/m^3$	[] O_3 Daily overcomes of 120 $\mu g/m^3$	Total coliform FCU/100 ml	Conductivity $\mu S/cm$	Organic carbon mg/l	DQO mg/l O_2	Nitrates mg/l	O_2 dissolved mg/l O_2	Cu mg/l
El Toro	51	11	72	648	1.7	5	1.2	11	0.001
Jérica	51	11	22	571	2.3	5	4.4	10	0.001
Lucena del Cid	50	16	4900	680	3.0	5	5.4	11	0.001
Montanejos	50	16	1700	1002	1.9	5	2.5	9.6	0.001
Onda	90	21	21	755	2.1	5	2.7	8.6	0.001
Puebla de Arenoso	50	16	108	398	2.3	5	1.0	11	0.001
Sot de Ferrer	51	11	6500	756	2.1	5	9.1	10	0.001
Vallat	50	16	52	552	1.7	5	2.4	9.4	0.001
Villareal	90	21	330	743	5.2	6	4.1	9.8	0.002
Ademuz	27	9	1800	507	3.4	5	4.3	9.6	0.001
Alborache	34	63	89,000	981	3.3	7	16	9	0.002
Algemesi	58	37	920,000	1541	3.6	8	30.0	8.1	0.001
Alzira	58	37	800,000	1516	3.3	9	27.0	8.1	0.001
Aras de Alpuente	27	9	4900	1334	3.1	5	8.1	9.4	0.015
Bellus	66	14	530	773	5.1	8	23.0	9.7	0.002
Benageber	27	9	15	1138	2.5	5	2.5	6.9	0.001
Bocairent	78	13	7900	466	1.1	5	6.7	8.3	0.001
Calles	27	9	45,000	774	1.6	5	10.0	9.6	0.001
Castelló de la Ribera	58	37	780	2160	3.3	10	16.0	8.6	0.002
Chulilla	27	9	64	750	1.8	5	4.2	8.3	0.001
Cofrentes	34	63	390	1143	1.5	5	5.5	12	0.001
Cullera	58	37	68,000	1578	4.4	8	28.0	8.8	0.001
Dos Aguas	34	63	72	762	1.8	5	3.4	9.8	0.001
Jalance	34	63	260	1335	1.8	5	8.9	12	0.005
Macastre	34	63	105	868	3.2	6	1.0	12	0.006
Manises	52	23	30,000	1159	2.3	5	22.0	9.8	0.001
Montaberner	66	14	1900	890	3.6	7	45.0	10	0.002
Quart de Poblet	52	23	68,000	1171	6.7	13	20.0	9.7	0.004
Requena	34	63	2700	1203	5.7	17	34.0	9.6	0.003
Sinarcas	27	9	480	986	3.3	5	11.0	8.9	0.002
Utiel	34	63	440	1338	6.4	10	6.8	8.4	0.001
Villanueva de Castellón	58	37	21,000	1041	3.6	5	38.0	10	0.002
Xátiva	66	14	17,050	1469	2.5	5	56.0	9.9	0.001
Yatova	34	63	14	883	1.5	5	6.3	8.8	0.001
Altea	64	62	1,710,000	1054	11.0	22	13.0	7.8	0.001
Alicante	64	62	5400	2280	5.1	12	13.0	10	0.003
Aspe	22	20	32,000	15,530	8.0	24	39.0	7.2	0.003
Beneixama	78	13	8300	714	5.3	14	6.7	6.2	0.001
Cocentaina	78	13	210,000	1057	11.0	20	19.0	7.4	0.038
Elche	64	62	1800	18,280	8.0	25	27.0	11	0.003
L'Orxa	78	13	6800	593	3.5	8	5.0	8.5	0.002
Monovar	22	20	9200	2690	15.0	60	72.0	4.6	0.002
Sax	78	13	70,000	7180	39.0	130	4.3	2.1	0.003
Tibi	78	13	48	3220	6.8	17	11.0	10	0.018

Municipalities	Soil					Biodiversity			
	Soil sealed has	Area affected by fire has	Area occupied by natural vegetation has	Irrigation land has	Area of protected territory has	Critically endangered species of fauna n° species/ha	Vulnerable species of fauna n° species/ha	Near threatened species of fauna n° species/ha	Near threatened species of flora n° species/ha
El Toro	0	1	9308	2	10,968	0	0.000272851	0	0.000272851
Jérica	39	68	4974	340	4033	0	0	0.000127747	0
Lucena del Cid	0	6637	12,249	52	983	0.000145096	0.000435287	0	7.25479E-05
Montanejos	0	1080	3408	40	2440	0.00026455	0.000529101	0.00026455	0
Onda	693	6	2627	3665	132	0	0	0	9.22339E-05
Puebla de Arenoso	0	1	3090	30	2407	0.000235128	0.000470256	0	0
Sot de Ferrer	1	2	280	73	281	0	0	0.001157407	0
Vallat	0	0	440	13	73	0.001996008	0	0	0
Villareal	950	0	0	3273	27	0	0	0	0
Ademuz	0	1	3036	177	9486	0.000199164	0.000199164	9.95818E-05	9.95818E-05
Alborache	3	15	1486	216	247	0	0	0	0
Algemesi	247	6	0	3049	255	0.00048216	0	0	0
Alzira	635	269	3271	5356	3292	9.05633E-05	0.000181127	9.05633E-05	9.05633E-05
Aras de Alpuente	0	2	7431	95	9910	0	7.22909E-05	0	0
Bellus	0	9	484	54	146	0.001048218	0	0	0
Benageber	0	2	6141	14	6973	0	0.000143225	0	0
Bocairent	65	4707	6922	86	6937	0	0.000103114	0	0.000309342
Calles	0	1373	5597	13	6716	0.000154943	0.000309885	0	0

Table 1 (*Continued*).

Municipalities	Soil					Biodiversity			
	Soil sealed	Area affected by fire	Area occupied by natural vegetation	Irrigation land	Area of protected territory	Critically endangered species of fauna	Vulnerable species of fauna	Near threatened species of fauna	Near threatened species of flora
	has	has	has	has	has	n° species/ha	n° species/ha	n° species/ha	n° species/ha
Castelló de la Ribera	355	205	445	302	3169	0	0	0	0
Chulilla	0	1769	2521	436	1649	0	0.000161865	0	0
Cofrentes	54	26	7730	113	7541	0.000193836	0	9.6918E-05	9.6918E-05
Cullera	355	105	445	3473	3169	0	0	0.000185805	0.000371609
Dos Aguas	0	7894	11,135	92	12,061	0	8.2291E-05	0	8.2291E-05
Jalance	38	5	6518	87	9165	0.000105519	0.000316556	0	0.00073863
Macastre	23	9	2121	123	1555	0	0.000796601	0	0
Manises	641	2	0	417	0	0	0.000508906	0	0
Montaberner	55	1	19	49	13	0	0	0	0
Quart de Poblet	726	0	0	722	10	0	0	0	0
Requena	315	5868	44,544	2871	27,656	3.68455E-05	6.14092E-05	0	6.14092E-05
Sinarcas	47	0	6386	291	4239	0	0.000195198	0	0.000292797
Utiel	263	4	8294	1060	8045	4.22101E-05	0	0	0
Villanueva de Castellón	101	21	20	1525	8	0	0	0	0
Xátiva	641	607	2478	2449	396	0.000130617	0.000130617	0	0
Yatova	29	2	10,094	216	8409	0	8.31601E-05	0	0.00016632
Altea	974	13	1048	592	678	0	0.000290444	0.000580889	0
Alicante	3802	1	4402	1598	1134	0	9.9369E-05	0	0.000248423
Aspe	314	27	1989	1620	618	0	0.000282087	0	0
Beneixama	69	117	1647	98	1506	0	0	0	0
Cocentaina	318	322	1968	148	2266	0	0.000188893	0	0.000566679
Elche	3669	61	4974	8277	6105	3.06683E-05	0.000153341	0	9.20048E-05
L'Orxa	0	75	2597	28	2480	0	0.000314861	0	0.000944584
Monovar	188	30	5623	1908	1779	0	6.5634E-05	0	0
Sax	159	1	1657	538	1686	0.00015753	0	0	0.00031506
Tibi	183	4	4729	25	1188	0	0.000142086	0	0.000142086

normalisation, weighting and integration of indicators (Wagenet and Hudson, 1997).

Transformation and normalisation can be done using value functions (e.g. Beinat et al., 1994a, 1994b; Karlen et al., 1994; San-José Lombera and Garrucho Aprea, 2010; Torres Sibille et al., 2009a, 2009b; Wymore, 1993). These functions show the relationship between the real measure of indicators and the quality of the resource measured, and its form depends on the relationship between the indicator and the quality of the resource (Conesa, 2010; Gómez Orea, 2003). Through the application of these functions, the different values of the selected indicators are expressed into a common unit (resources quality units) within the same dimensionless scale, which ranged from 0 to 1. However, in many cases, there is no scientific evidence for establishing an appropriate specific relationship between indicator and quality. In such cases, data can be transformed and normalised according to the maximum (max) and minimum (min) values of each indicator considered in the study area (Recatalá, 2009). This was the procedure applied in this work, as it is done in EIA studies (Conesa, 2010; Gómez Orea, 2003). Moreover, the same weight was given to each indicator in order to avoid the controversy existing in the scientific community related to weighting (Cendrero, 1997; Diaz de Teran, 1985). Integration of indicator values was done using an additive algorithm considering the independence between them (Cendrero and Fischer, 1997) after having applied PCA. Further details on the assessment procedure followed can be consulted in Sacristán (2009).

The resources quality of each municipality was established by applying the following expression:

$$RQ_m = \sum_{i}^{n} Q_i \qquad (1)$$

where RQ_m = resources quality of municipality m, Q_i = quality of resource i; n = number of resources considered in the municipalities.

In order to compare the resources quality between different municipalities, a global quality evaluation scale was developed, using an interval scale with 5 classes from the maximum and minimum global quality identified in the study area. This number of classes is enough to properly discriminate different municipalities in terms of resources quality within the Mediterranean Region (Recatalá et al., 2009a). Resources quality of the municipalities selected was represented in a map.

Environmental impacts on municipalities derived from the land-use planning instrument considered in the demonstration exercise mentioned above were assessed through the changes in terms of the resources quality (soil and biodiversity at this level). For that purpose the following expression was applied:

$$I_m = RQ_{mf} - RQ_{mi} \qquad (2)$$

where I_m = environmental impact produced on municipality m by the land-use planning instrument, RQ_{mi} = resources quality of municipality m before the implementation of the planning instrument, and RQ_{mf} = resources quality of municipality m after the implementation of the planning instrument.

This expression is consistent with the usual procedure for assessing an environmental impact as stated by several authors (e.g. Conesa, 2010; Canter, 2003; Gómez Orea, 2003) that implies the measure or estimation of changes on natural resources caused by human actions.

Thus, environmental impacts assessed in each municipality were actually global impacts as resources quality referred to an integration of the quality of several natural resources (soil and biodiversity in this case study). The value of resources quality for each municipality before the implementation of the planning instrument was calculated through the collected data from the databases and sources of information pointed out above, whereas the value after the implementation of the planning instrument was estimated considering the effects of this planning instrument on natural resources (soil and biodiversity). When evaluating the resource soil, the effect derived from an urban-industrial expansion plan was assessed by considering that the area devoted to urban or industrial uses increases by 50%, which is the mean occurred in the Valencian Mediterranean region in the last decades (OSE, 2007; Salom, 2010), as indicated before. This increase results in a decrease of the area devoted to another use, and normally relays both in agricultural and natural vegetation area. The decrease in agricultural areas is associated to expansion processes of the city centre while the decrease in natural vegetation areas is associated to the construction of low density housing developments (Recatalá et al., 2000). It was considered that 25% of the increase in the area of soil sealed was associated to an expansion process in irrigated lands, while the other 25% corresponded to soil sealed in natural vegetation area. When considering biodiversity, it was estimated that the implementation of the plan would mean the loss of biodiversity as a consequence of soil sealing. This loss was considered to be proportional to the loss of the Area occupied by natural vegetation. This means that the biodiversity of each municipality decreased 25%.

Specifically, for the demonstration exercise, the municipalities selected were Sinarcas, Macastre and Altea, since they were representative of the Inland, Intermediate and Coastal zones of the Valencian region (Fig. 1), respectively, and also of the European Mediterranean Region. For these municipalities, the indicators referring to Soil sealed, Irrigated land area, Area occupied by natural vegetation, number of Near threatened species of fauna and number of Vulnerable species of fauna were considered to assess the environmental impacts generated by the hypothetical land use plan proposed. For that purpose, these indicators were recalculated considering the urban-industrial increase specified previously. In each municipality, environmental impacts were calculated by applying the expression (2), expressed in terms of quality units and referred to the same scale, which ranged from 0 to 1, as usually done elsewhere (e.g. Conesa, 2010; Dee et al., 1973; Gómez Orea, 2003; Westman, 1985; Whitman et al., 1973).

The estimation of the reduction in costs of applying the minimum indicator set was done calculating the costs of measuring the indicators eliminated from the initial set and considering that these would have to be evaluated in all the municipalities identified.

Regarding the water quality indicators, it was considered that, in average, the indicators would be sampled 3 times in 3 different points of the municipality (Rueda et al., 2008).

In order to estimate the cost of evaluating the Area affected by fire, it was considered that an expert would take approximately 5 h to identify the area using aerial photographies, delimit the territory affected by a fire and calculate the area in a GIS (Geographical Information System) framework; and at least one day of field work to corroborate the area identified and delimited (Yáñez, 2013).

Finally, to estimate the amount saved when evaluating the biodiversity indicators, it was considered that it would be necessary to do a global census of species present in the study area. At municipality level, this census is done by dividing the territory into squares of 1 km^2 and the presence of species is determined in each of them. According to Encabo et al. (2005), to determine the birds species present, 2 samplings of 1 h each must be done for every square kilometre and to determine the presence of mammals different traps must be layed out and collected, which would take an average of 4 h. According to Sasa et al. (2008) to determine the presence the different species of fish, amphibians and reptiles, for each 1 km^2, 2 samplings of 2 h would be needed. According to Rueda et al. (2008) to determine the presence of invertebrates, again, 2 samplings of 2 h each must be carried out for every square kilometre; and finally, according to Vera et al. (2006), in order to do a census of the flora of each 1 km^2 area, 3 samplings of 4 h each would be needed. Therefore, the total amount of hours per square kilometre would be of 30 since all the censuses have to be carried out independently, according to these authors (Rueda et al., 2008; Sasa et al., 2008; Vera et al., 2006; Encabo et al., 2005).

Table 2
Eigenvalues obtained after the application of PCA to the initial set of indicators.

Principal Component	Eigenvalue	Proportion	Cumulative
1	4.737	26.316	26.316
2	2.603	14.463	40.779
3	1.806	10.034	50.813
4	1.450	8.054	58.867
5	1.294	7.188	66.055
6	1.239	6.882	72.937
7	0.946	5.255	78.192
8	0.852	4.735	82.927
9	0.742	4.122	87.049
10	0.623	3.462	90.511
11	0.472	2.620	93.131
12	0.349	1.939	95.071
13	0.257	1.429	96.500
14	0.212	1.180	97.680
15	0.198	1.101	98.781
16	0.135	0.751	99.532
17	0.051	0.282	99.814
18	0.034	0.186	100.000

3. Results and discussion

The results obtained from the PCA analysis are shown in Tables 2 and 3.

In order to define a minimum indicator set the first six principal components (PCs), which accounted for 72.9% of the total variance (Table 2), were considered. The reasons were: firstly, their eigenvalues were >1 and, therefore, relevant according to the Kaiser–Goodman criterion; and secondly, these 6 PCs included all of the resources selected previously and covered their most important functions (Yu et al., 1998).

Table 3 shows that the first PC had high positive coefficients (loadings) with the indicators that referred to water quality, on one hand, and the use of the resource soil, on the other. More precisely, the indicators with high positive coefficients were: Conductivity (0.728), Organic C (0.828), DQO (0.818), Nitrates (0.699), Total Coliform (0.610), Soil Sealed (0.773) and Irrigated Land (0.717). The relation between this set of indicators seemed logical and adequate since the water quality indicators can identify contamination processes of this resource due to urban-industrial uses and intensive agriculture associated to irrigation land. Therefore, this PC represented the quality of the resource water associated to the exploitation of the resource soil.

The second PC had high positive loadings with Area of protected territory (0.775) and Area occupied by natural vegetation (0.824). Therefore, this component refers to soil quality.

The third PC had a high positive loading with O_3 (0.661). This loading was the highest, so this PC referred to the air dimension of the environment. More precisely, this PC represented the air quality in rural areas, according to several authors (Calatayud et al., 2007; Sanz et al., 2007).

The fourth PC had a high positive loading with Near threatened species of fauna (0.511). Therefore, this PC represented the quality of the resource biodiversity, considering the component fauna.

The fifth PC had high positive loading with NO_2 (0.606) and therefore referred to the quality of air, such as PC three. But this time, the highest positive loading relied in an air quality indicator of urban areas, according to several authors (Calatayud et al., 2007; Sanz et al., 2007).

Finally, the sixth PC had a high positive loading with Vulnerable species of fauna (0.640). Again, this PC represented the quality of the resource biodiversity and considered the component fauna.

Table 3
Loadings (eigenvectors) obtained after the application of PCA to the initial set of indicators.

Indicators	Principal Components					
	1	2	3	4	5	6
NO_2	0.250	−0.279	−0.209	−0.220	0.606	−0.418
O_3	0.319	−0.060	0.661	−0.146	−0.211	−0.168
Conductivity	0.728	0.288	0.048	−0.021	−0.274	0.166
Organic C	0.828	0.236	−0.352	0.051	−0.034	0.020
DQO	0.818	0.383	−0.293	0.115	−0.052	−0.024
O_2 dissolved	−0.531	−0.312	0.523	−0.327	0.031	0.170
Nitrates	0.699	−0.178	0.258	0.154	0.022	0.261
Total Coliform	0.610	−0.123	0.046	0.336	0.457	0.318
Cu	0.398	0.380	−0.154	−0.506	0.064	0.291
Soil sealed	0.773	−0.215	0.322	−0.247	0.019	−0.221
Area affected by fire	−0.023	0.447	0.492	0.334	0.299	0.145
Area occupied by natural vegetation	−0.268	0.824	0.210	0.156	−0.044	−0.167
Irrigated land	0.717	−0.226	0.395	0.069	−0.156	−0.135
Area of protected land	−0.194	0.775	0.180	0.137	−0.121	−0.326
Critically endangered species of fauna	−0.251	−0.144	−0.334	0.368	−0.119	−0.008
Vulnerable species of fauna	−0.307	0.331	0.107	−0.172	0.256	0.640
Near threatened species of fauna	−0.048	−0.093	0.217	0.511	0.433	−0.165
Near threatened species of flora	0.048	0.483	−0.004	−0.467	0.437	−0.255

Taking into account the results obtained, the second set of environmental indicators selected included:

(1) Air: NO_2 and O_3. The selection of this two indicators allowed evaluating the quality of air in two well-differentiated areas: urban and rural, as explained above.
(2) Water: Organic C, Conductivity, Nitrates and Total Coliform. Including these indicators will allow detecting different contaminating sources in the resource water. It is important to stand out that DQO was not selected due to its strong relationship with Organic carbon, avoiding this way overestimation and therefore, bias in the evaluation of the resources quality.
(3) Soil: Soil sealed, Irrigated Land area, Area of protected territory and Area occupied by natural vegetation. These four soil quality indicators selected allowed evaluating the different functions of soils explained above. On one hand, Soil sealed and Area affected by fire represent the area where the productivity and ecological function, respectively, has been strongly affected, provoking in some cases its complete loss. On the other hand, Irrigated land area, and Area of protected territory and Area occupied by natural vegetation represent the opposite, areas where the productivity and ecological function, respectively, are in its highest quality status. For this reason, in order to evaluate the multifunctionality of soil at regional level, these indicators had to be selected. In addition, the last two indicators included also the quality of the resource biodiversity, referred only to the component flora, since most of the plant species richness of a certain territory is found in these areas.
(4) Biodiversity: Near threatened species of fauna and Vulnerable species of fauna. These indicators allowed evaluating the fauna component of the quality of the resource biodiversity.

Therefore, from an initial set of 18 indicators, a second set of 12 indicators was created. The resources quality of the municipalities selected from the Valencian region, assessed by applying this minimum indicator set, is shown in Table 4 and Fig. 3.

The results obtained with this set of indicators were very similar to those obtained in another study done by other authors in the same area (Recatalá et al., 2009b). But, in that case, the authors assessed the resources quality of the whole Valencian region using a broader set of environmental indicators. This clearly indicated the applicability and usefulness of the set environmental indicators developed in this work when assessing the resources quality at municipality level, as fewer efforts are needed in collecting and processing data than in a precedent proposal. These are relevant issues in terms of time and costs when applying environmental indicators.

Regarding the water quality indicators, considering the sampling procedure stated before and that the cost of determining dissolved O_2 is of 18€/sample; of 20€/sample for DQO and of 20.51€/sample for Cu concentration (www.labocheck.com), the amount saved when evaluating the water quality of one municipality will be of 526.59€. Since 44 municipalities are being studied, the total amount saved would be of approximately 23,169.96€.

For evaluating the area affected by fires, the cost per hour of an expert would be of 40€ and a day of field work would cost 150€ (CECCAA, 2012). Therefore, the total amount per municipality would be of 350€ and for the 44 municipalities considered would be of 15,400€.

The amount saved evaluating the biodiversity would be of 1200€ per km^2, considering the total amount of hours and the cost of hiring an expert specified previously. Taking into account that the total area of the municipalities evaluated is of 4093.10 km^2, the total amount saved would be of 4,911,720€.

Therefore, the global amount saved for the 44 municipalities considered would be of 4 950,289.96€. When applying all these calculations to the municipalities considered initially (152), the global amount saved would be of 12,132,137.68€, which is not a significant part of the regional GDP (only represents 0.012%) but corresponds, for example, to approximately half of the total amount of money invested by the Valencian Regional government in maintaining and improving all the infrastructures in the area of agriculture in the whole region (DOGV, 2013). The current economic situation of most of southern Europe and especially the Mediterranean basin, characterised by austerity budgets and uncertainty, makes necessary to keep costs as low as possible. Hence, the minimum indicator set established in this research can be very useful to this respect. These savings (112,481.85€ per municipality as an average) could be invested at municipality level in improving services (e.g. education, health) and goods that are being reduced due to the actual economic crisis.

When assessing the environmental impacts on natural resources derived from the implementation of the hypothetic land use planning instrument explained in the previous section that concerned an urban-industrial expansion situation, interesting results were obtained (Table 5). The impact generated over the soil and biodiversity quality would have a differential effect in terms of resources quality values for the different municipalities

Table 4
Resources quality value and class for the selected municipalities.

Municipalities	Resources quality value	Resources quality class	Municipalities	Resources quality value	Resources quality class
El Toro	0.7043	Very high	Dos Aguas	0.6274	High
Jérica	0.6470	High	Jalance	0.6247	High
Lucena del Cid	0.6815	High	Macastre	0.6521	High
Montanejos	0.7029	Very high	Manises	0.6110	Moderate
Onda	0.5122	Low	Montaverner	0.5439	Low
Puebla de Arenoso	0.6808	High	Quart de Poblet	0.5436	Low
Sot de Ferrer	0.6983	High	Requena	0.6532	High
Vallat	0.6188	Moderate	Sinarcas	0.6824	High
Villareal	0.4968	Low	Utiel	0.5691	Moderate
Ademuz	0.7115	Very high	Villanueva de Castellón	0.5089	Low
Alborache	0.5404	Low	Xátiva	0.5124	Low
Algemesi	0.4543	Very low	Yatova	0.6094	Moderate
Alzira	0.4734	Low	Altea	0.4601	Very low
Alpuente	0.6936	High	Alicante	0.4241	Very low
Bellus	0.5694	Moderate	Aspe	0.5297	Low
Benageber	0.6996	High	Beneixama	0.5792	Moderate
Bocairent	0.6268	High	Cocentaina	0.5575	Moderate
Calles	0.7079	Very high	Elche	0.2843	Very low
Castelló de la Ribera	0.5482	Moderate	L'Orxa	0.6256	High
Chulilla	0.6758	High	Monovar	0.5241	Low
Cofrentes	0.6008	Moderate	Sax	0.4689	Low
Cullera	0.5126	Low	Tibi	0.5775	Moderate

considered. Specifically, the execution of the urban-industrial plan would produce an impact of −0.0177 qu (quality units) in the coastal municipality (Altea) considering a scale between 0 and 1 as explained before; of −0.0206 qu in the intermediate (Macastre); and of −0.0050 qu in the interior one (Sinarcas). These results indicate that the interior municipality will have the lowest impact in terms of magnitude, understood as the change that would be produced in terms of quality units (Gómez Orea, 2003), if the plan was finally implemented in it. This is due to the fact that interior municipalities tend to have small city centres, representing a small percentage of the total municipal area. For this reason, an increase of 50% in the area of soil already sealed does not result in an important increase of this area, and therefore, does not affect significantly the area devoted to other uses, like Irrigated land or Area occupied by natural vegetation. However, although the impact is not important in magnitude, it is important in terms of relevance (Gómez Orea, 2003; Recatalá, 1995, 2009) as very high quality resources (soil and biodiversity) would be affected and destroyed. Thus, the impact generated in this municipality would be critical and, therefore, this municipality should not be considered the most adequate to propose this expansion plan, even though it does not result in an important increase of the soil sealed. The other municipalities (intermediate and coastal) would undergo a higher impact in terms of magnitude due to the implementation of this expansion plan, being greater the impact that would be generated in the intermediate one in terms of resources quality units, as expressed above. This greater impact in the intermediate municipality would be due to the fact that these municipalities tend to have a higher biodiversity and, therefore, an urban-industrial expansion plan would have a greater impact in them.

Considering the relevance of the impacts in terms of the quality of the resources affected, the best option to implement the hypothetic urban-industrial plan would be the coastal municipality, since the initial quality of the resources is low. In addition, the impact calculated corresponds to a change produced in the lower part of the resources quality class scale proposed (between 0 and 1), making it, therefore, less relevant. Furthermore, it is important to consider that these municipalities include relevant socioeconomic aspects for the expansion of urban-industrial uses, such as high accessibility and good infrastructures/facilities, making them more suitable for the implementation of this type of plans.

However, coastal municipalities usually have highly productive soils, which are classified of high quality in terms of productivity. In fact, soils of high quality in terms of productivity have been lost due to expansion of urban-industrial uses in several municipalities of the Valencian region for the last decade (OSE, 2007; Recatalá et al., 2009a). An example of a municipality that has undergone this impact in a very intensive way is Benetusser. According to official data (Sánchez et al., 2007), in 1998, 94% of the total area of this municipality had been sealed and had been used for urban-industrial purposes. Nowadays, nearly the whole of the municipality is built-up. This means a critical and of high intensity impact on soil has occurred in the entire municipality because a very high quality soil resource has been completely destroyed by sealing.

In order to avoid situations similar to that occurred in the municipality of Benetusser, plans that propose expansion of urban-industrial uses in coastal municipalities should seek for areas that already have a high level of building activity. As discussed by Recatalá et al. (2000) in a land use planning exercise done in the Valencian Mediterranean region, the presence of such activity and other attributes (e.g. high accessibility) can be sufficient to justify the loss of good agricultural land in favour of urban-industrial uses.

It is important to highlight that between 1987 and 2000, more than 25,000 ha of good agricultural land and about 5000 ha of areas occupied by natural vegetation have been lost in the Valencian region due to urbanisation (OSE, 2006) and this process has progressively continued until 2008, when the present economic crisis

Table 5
Resources quality values of Altea, Macastre and Sinarcas before and after the implementation of a hypothetical urban-industrial expansion plan and the consequent environmental impact values.

Municipality	Zone	Resources quality value BEFORE the plan	Resources quality value AFTER the plan	Impact value
Altea	Coastal	0.4601	0.4424	−0.0177
Macastre	Intermediate	0.6521	0.6315	−0.0206
Sinarcas	Inland	0.6824	0.6774	−0.0050

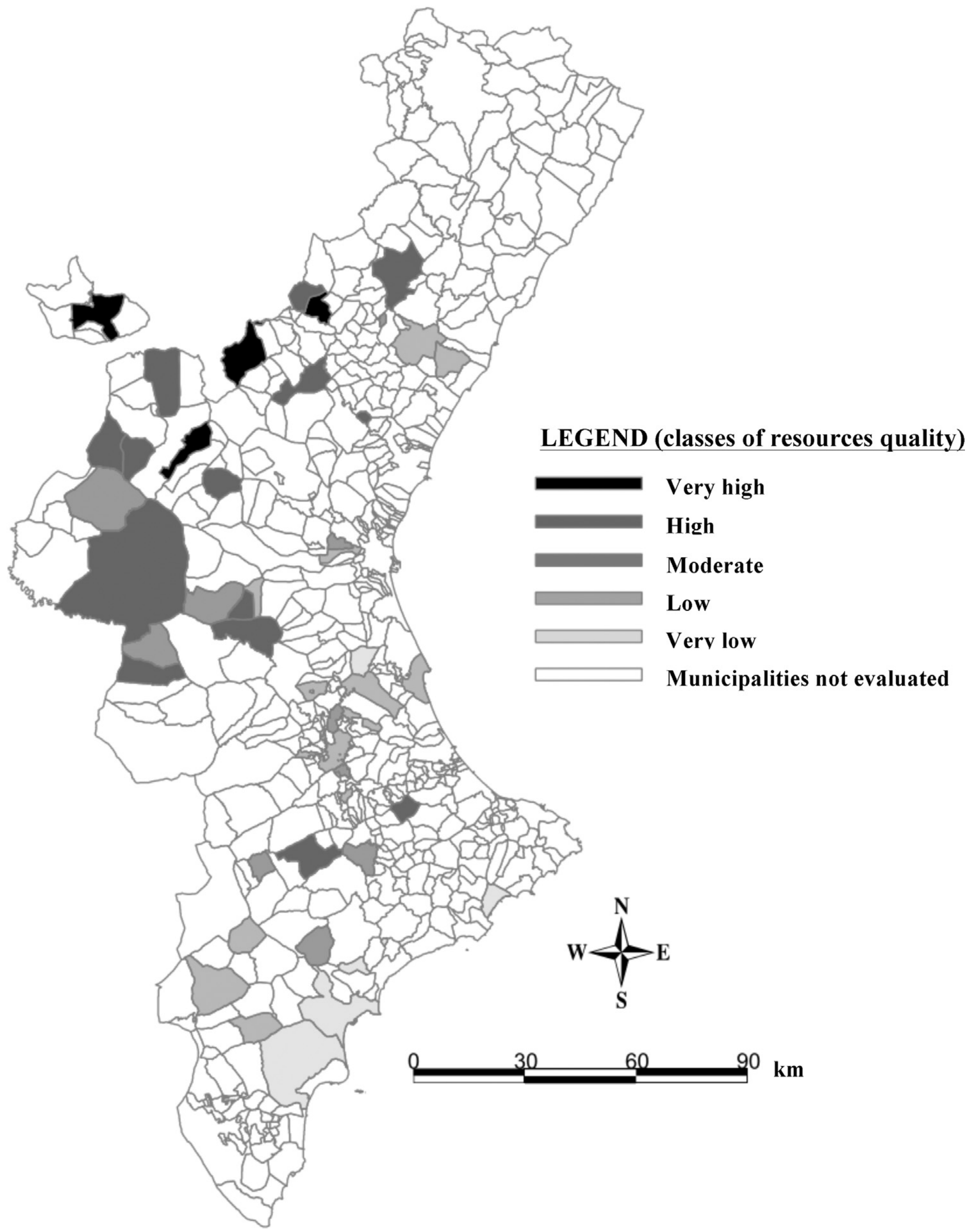

Fig. 3. Resources quality class of the selected municipalities.

started (Recatalá, 2009). Urbanisation has also been an important process in Europe, leading to the deterioration and even destruction of natural resources. According to the European Environment Agency and the Joint Research Centre, urbanisation caused the loss of more than 900,000 hectares of agricultural land in Europe during the period between 1990 and 2000 (EEA and JRC, 2010) and this trend continued in the period 2000–2006 (EEA, 2010a). Non-agricultural land including areas of high biodiversity (e.g. wetlands) is also consumed by urbanisation (EEA, 2010b). Consequently, application of the indicator set defined in this work is highly needed in the Valencian region, in the Mediterranean Region and in all Europe in order to prevent the environmental impacts on soil and biodiversity associated with urbanisation.

In synthesis, the results obtained showed that the minimum indicator set defined through a PCA analysis was adequate to assess the change in terms of quality for the different resources considered and, therefore, adequate for the assessment of the impacts generated by land use planning instruments, as required by the EIA Valencian legislation (DOGV, 1989, 1990, 2005, 2006), the EIA Spanish Law and Regulations (BOE, 1986, 1988, 2000, 2001, 2006, 2008, 2010, 2013a) and the EIA European Directive (DOCE, 1985, 1997, 2001, 2012), especially when urban-industrial expansions are proposed.

The economic relevance of the minimum indicator set defined has also been demonstrated. Although the reduction of costs is not significant in terms of the regional GDP, the potential amount saved is relevant when considering the regional investment in some areas. The amount of money saved could cover, for example, half the costs of maintaining and improving all the infrastructures in the area of agriculture in the whole Valencian region (DOGV, 2013).

In addition, it must be pointed out that data were selected from official, easily accessible and updated sources of information, which guaranteed it were recent and consistent, a very important issue to take into account when assessing environmental impacts. However, it is important to stand out that further efforts need to be made in order to improve the quality of environmental data at municipality level. As commented before, environmental data were missing for some municipalities and when available, they were not easily accessible. Consequently, in order to improve environmental assessment, institutions and administrations need to do greater efforts in order to generate adequate environmental data.

4. Conclusions

Environmental assessment is a useful tool to evaluate impacts derived from human actions over the natural environment. In order to facilitate the assessment of resources quality and, at the same time, reduce costs in the acquisition of information, the use of a minimum indicator set is a key issue.

PCA was applied to an initial set of 18 indicators that represented the main environmental resources (Air, Water, Soil and Biodiversity) that have to be considered when assessing environmental impacts from land use plans and projects. After having analysed the different principal components generated, the first six were selected, which accounted for 72% of the total variation of the whole system. A set of 12 indicators was defined from these PCs after analysing the coefficients/loadings that the different initial indicators had in each one of them. This minimum indicator set was used to assess the resources quality of the selected municipalities from the Valencian Mediterranean region. The results obtained were very similar to those obtained by other studies done for the same area but with a different and broader set of indicators (Recatalá et al., 2009b).

In addition, the amount of saved money estimated if the minimum indicator set defined was applied has been demonstrated to be important. Regional governments have introduced severe budget cuts due to the current economic crisis and the amount of saved money estimated has proved to be enough to cover, for example, some of the costs of certain areas like agriculture for the whole Valencian region (DOGV, 2013).

Therefore, the minimum indicator set defined here is adequate to assess the resources quality of municipalities of the Valencian region and leads to an important reduction of costs in the acquisition and processing of information.

When the implementation of a hypothetic urban-industrial expansion plan was considered in three representative municipalities of the region, the application of the minimum indicator set showed its usefulness for assessing the environmental impact that would be provoked by this type of plans. According to the results obtained in terms of impact magnitude, the most suitable municipality to implement this plan seemed to be an inland one (e.g. Sinarcas). However, in these municipalities the initial quality of the resources that can be affected are usually very high, and therefore a critical impact, in terms of relevance, would be generated after the implementation of the plan. Thus, considering the relevance of the impacts generated, a coastal municipality (e.g. Altea) would therefore be the most suitable option to implement the plan. However, coastal municipalities frequently hold high quality soils in terms of productivity. For this reason, and in order to minimise the impact over high quality soil resources, areas already having a high level of building activity must be identified and proposed for the implementation of this type of plans (Recatalá et al., 2000).

Given that the environmental issues considered in the Valencian region are representative of the European Mediterranean Region, it follows that the approach developed in this work can be useful to predict and monitor environmental impacts on natural resources from planning instruments and from projects in the whole region. Considering the impacts provoked by urbanisation in the Valencian region and in all Europe in terms of loss of good agricultural land and of areas having high biodiversity, it follows that the application of the indicator set defined in this research is strongly recommended both in the Valencian Region and in other parts of Europe and can be, therefore, a useful method to assess environmental impacts according to the EIA legislation. Nevertheless, in order to better accomplish this purpose, more efforts in developing adequate environmental data at municipality level are urgently needed.

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