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In landscape management all of us have something to say. A holistic method for landscape Preservability evaluation in a Mediterranean region

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ABSTRACT

Landscape assessment methods have traditionally valued the landscape through a panel of experts with little or no participation of the population. However, after the adoption of the European Landscape Convention (ELC), the perception and the participation of the population has played an increasingly important role in landscape evaluation and planning. In this regard, the goal of this paper is to develop a model able to evaluate and integrate both the objective and subjective landscape factors into a new concept: the Preservability. This model, as well as selecting and classifying the landscape attributes according to the bio-geographic features of the study area i.e., Ricote Valley (Region of Murcia, Spain), includes two online surveys: one to assess the populationís landscape preferences and the other to obtain the specific weight of each objective and subjective landscape factor from a panel of experts. These landscape factors were incorporated into a GIS. To obtain the best model, the Preservability was assessed from three different approaches: objective, objective-weighted and weighted. The final results demonstrate how the Preservability weighted method returns different thresholds appropriate to the landscape attributes, the population's perceptual preference and the protected areas. The different thresholds allows for priority areas to be identified for protection, as well as the adoption of appropriate management and planning strategies according to the landscapes characteristics, current state and uniqueness.

1. Introduction

Landscape evaluation has evolved gradually over time until its present state. The European Landscape Convention (ELC) (Council of Europe, 2000) was the first policy which elevated its importance (Priore, 2007) and considered it an asset comparable to other resources (e.g., vegetation, soil, wildlife, etc...). As a result, this contributed to the development of a theoretical and practical framework for urban planning (De Montis, 2014).

According to the ELC, landscape is "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors". It constitutes a scarce and valuable natural resource with a growing demand, but is easily depreciated and difficult to renew (Maero et al., 2011; Muñoz-Pedreros, 2004; Picher Fernández et al., 2006). Its importance to natural heritage, culture, quality of life and society is evident (Andrews and Withey, 1976; Antrop, 2000a; ELC). Therefore, its consideration and exhaustive evaluation is required despite the strong perceptual component that can impede its analysis.

According to several authors there are different methodologies for assessing landscape (e.g., Arthur et al., 1977; Briggs and France, 1980; Daniel and Vining, 1983; Zube et al., 1982). Lothian (1999) split the different approaches into two main paradigms of landscape evaluation: objective or physical and subjective or psychological. In the first methodology, it is assumed that beauty is an inherent quality of the landscape and is dependent on its intrinsic attributes. In the second methodology, it is the product of the multisensory composition of the visual receptor: "the eye of the beholder". By merging these two paradigms we are able to use a more effective method which focuses on the objective aspects using progressive quantification complemented by subjective studies (Buhyoff and Riesenmann, 1979; Wherrett, 1996).

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There is now a general consensus that both aspects (objective and subjective) are important and must be treated with the rigour and the scope necessary for the proper evaluation of landscape (Sheppard, 2005). However, the relative weight of each aspect is still unclear when trying to assess landscape. This uncertainty has led to various studies that focused separately on one of the two methods i.e., objective or subjective.

In regards to numerous subjective studies which have been conducted (e.g., Brown and Brabyn, 2012; Daniel, 2001; Misgav, 2000; Sevenant and Antrop, 2010; Zube et al., 1982), the visual perception is considered an essential component in understanding and appreciating landscapes which have a strong psychological and cultural dependency. Svobodova et al. (2012) distinguishes between two types of studies associated with visual perception. On the one hand we have the expert approach (Zube et al., 1982) or ecological model (Daniel and Vining, 1983), which is dominant in environmental management (Daniel, 2001) and where the evaluation is carried out by a group of experienced observers (e.g., Amir and Gidalizon, 1990; Bishop and Hulse, 1994). On the other hand, we have the participative or psychophysical approach (Daniel and Vining, 1983; Zube et al., 1982), where the evaluation depends on the general public (e.g., Arriaza et al., 2004; Barroso et al., 2012; Brown and Brabyn, 2012; Dramstad et al., 2006).

Therefore, the ELC has relegated the traditional methods of landscape evaluation by experts and prioritizes a more democratic method involving the population (Gulinck et al., 2001; Sevenant and Antrop, 2009, 2010). The recommendations by the ELC are understandable given the wide range of landscapes which have to be managed. However, these studies of perception by the population present a number of weaknesses: (1) the variation between landscapes is greater than between the judgments of observers (Daniel, 2001), (2) the significance of different intrinsic components that make up a landscape tends to be overlooked (Lothian, 1999), (3) there tends to be a positive bias in the results obtained from the inhabitants of the studied location (Zube et al., 1974; Dramstad, 1996), and above all, (4) using the results as a spatial criterion presents problems for land management and delimitation due to the lack of a recognizable limit.

From our study's point of view, we believe that these limitations of visual perception are overcome by integrating its strengths with an objective-based approach to create a new methodology within the quantitative holistic paradigm. According to Daniel and Vining (1983), this is the most rigorous and extensive approach to landscape evaluation. The main problem with this, however, is demonstrating which approach – i.e., objective or subjective – has the greatest impact on the final evaluation value. To resolve this issue we have used an expert consensus within the study. This merging of methods, recommended by Daniel (2001), has a twofold positive effect: Firstly, if the average or majority opinion of the experts is conducted correctly, it allows us to consider the weighting of physical and psychological values objectively, thus resolving the problems of the aforementioned method. Secondly, the role of the experts acquires greater relevance in relation to the visual preferences of the population, therefore minimizing the subjectivity of the method. In this way, the role of the expert can be defined as the reviewer of the selected model to assess the landscape.

Thus, the aim of this paper is to develop a method of landscape evaluation that combines the advantages of traditional objective procedures (inventory of intrinsic attributes) and subjective procedures (perception-based assessment) (Lothian, 1999), through a DELPHI survey conducted with a panel of experts. To determine what method fit better to reality, we are going to evaluate separately and together each one of the different objective and subjective procedures.

The methodology was applied in the Ricote Valley, in Southeastern Spain. The Valley shows high environmental and cultural landscapes as result of human intervention over the environment along the ages. The Valley's landscapes has a lot of similarities with another Mediterranean landscapes, with also displays some peculiarities, especially fluvial terraces where traditional orchards are located.

$$Pb = \frac{\sum_{i=1}^{n} Q_i + \sum_{i=1}^{n} F_i + \sum_{i=1}^{n} Ve_i + \sum_{i=1}^{n} Vq_i + \sum_{i=1}^{n} Vpf_i}{Sup_i}$$

Fig. 1. General equation for Preservability according to the proposed model.

2. Methodology and sources

The combination of explanatory variables selected to make up the landscape analysis model proposed in this paper allows us to revisit a concept defined by Bosque Sendra et al. (1997): the Preservability.

For Preservability (Pb) we understand "that landscape feature which allows us to determine on the basis of objective and subjective factors, the degree of protection each landscape unit deserves". It is a value used to classify the landscape hierarchically to determine its level of protection. It integrates the common objective factors of landscape like Quality (Q), Fragility (F) and Visual exposure (Ve), as well as the subjective Visual quality (Vq) and Visual perceptive fragility (Vpf) (Fig. 1).

Quality (Q) would be those features of the landscape that represent aesthetic, unique and natural values. The Fragility (F) is the capacity of the landscape to absorb physical changes without transforming its character significantly i.e. a way of establishing the vulnerability of the landscape (Muñoz-Pedreros, 2004). It is a term similar to that established by Amir and Gidalizon (1990) as Visual Absorption Capacity (VAC). For this paper the Q and F are an objective property inherent in the physical characteristics of the landscape (Lothian, 1999) and their value is calculated on the basis of the sum of the different attributes that make up the landscape. Visual exposure (Ve) is the part of the study area which is visible from specific viewpoints (Llobera, 2003). Preston (2001) demonstrated that the evaluation of scenic quality not only involved the populationís preferences, but also the degree of landscape visibility, as visible areas are more valued than non-visible areas (Brown and Itami, 1982). Due to the Ve factor compensating for the low scores of units nearest to the viewpoints, we applied a correction coefficient. This was done by multiplying the Ve value of those units whose Q value was less than their average minus the standard deviation by −1.

Visual quality (Vq) and the Visual perceptive fragility (Vpf) are the perceptual or subjective concepts which respectively express the subjective interpretation of the observer for each landscape unit (Lothian, 1999), and the sensitivity of a landscape unit to possible transformations. Finally, Sup represents the surface area of each landscape unit expressed in hectares whose estimation allows its results to be standardized, and i each pixels of the study area.

To obtain this model, a methodology is followed (Fig. 2) made up of four steps: (1) define the landscape units and delimit the study area, (2) conduct a survey of the landscape Visual Quality (Vq) and Visual Perceptive Fragility (Vpf) and an assessment of the results, (3) select the attributes of the landscape and (4) calculate the Preservability (Pb). We will now look at these steps in more detail.

The steps shown at Fig. 2 were evaluated and analyzed by the free GIS gvSIG Desktop 1.12 (http://www.gvsig.org), with the spatial extension Sextante and the Rstudio (R Core Team, 2014) statistical software.

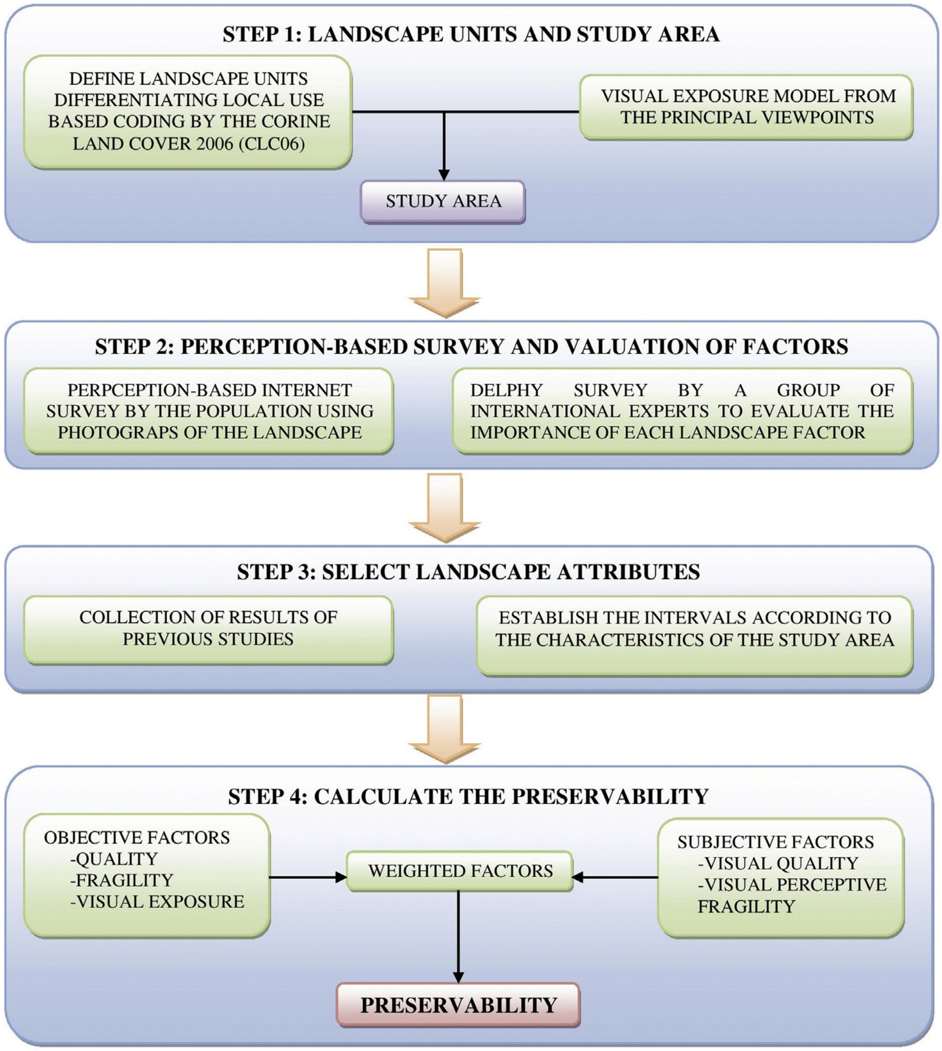


Fig. 2. Main stages of the methodology to calculate the Preservability.

2.1. *Define landscape units and delimit the study area*

The complexity of the landscape requires its structure to be divided into more manageable units (Antrop and Van Eetvelde, 2000), which are structures in a hierarchical and spatial way (Antrop, 2000a). The division of the different landscape units was based on the CORINE Land Cover (CLC) database (e.g., Arriaza et al., 2004; Gulinck et al., 2001; Schirpke et al., 2013). The CLC for 2006 (CLC06), seamless vector database version 16 (EEA, 2012), represents one of the key digital European cartographic databases for environmental assessment (Smith and Wyatt, 2007) from which various landscape attributes can be obtained. The CLC also allows you to delimit, more or less uniformly, different landscape units after their digitization and taxonomic reclassification. This is important as one of the limitations of the CLC is the absence of certain types of local land uses (Gulinck et al., 2001).

Secondly, the delimitation of the study area was performed in four steps:

i Definition of the viewpoints: major urban centres and the busiest roads (Wu et al., 2006).
ii Define the viewshed: using a digital elevation model (DEM) with a resolution of 25 m × 25 m and elevated viewpoints of 1.5 m (eye-level height) from its original altitude. Both layers were combined in the “visual exposure” algorithm of the software gvSIG by selecting the option “cumulative viewshed” with a limit of 5000 m. According to Hart (1992), the human eye is not able to differentiate between two items with a height of less than 1.45 m at that distance. This is the average height of vegetation typically found within the Mediterranean region.
iii Selection of the total number of landscape units of the CLC06 that intersect the viewshed including units within the surrounding zones. In order to avoid possible errors due to missing data, CLC06 units not visible to the naked eye within the study area were included.
iv Differentiate local land uses. After defining the study area we added a new type of landscape unit. This unit consists of unique characteristics which needed to distinguish it within the existing classification (CLC06), *genius loci*, (Antrop, 2000b) and for consideration in spatial analysis: the traditional orchard. Using the 1:25000 scale we digitized these units on screen.

For this case study, the landscape units and the viewpoints were defined on a representative area in the Mediterranean Region: the Ricote Valley (Region of Murcia, Spain, 38°0′5″—38°23′38″ North and −1°9′32″—−1°38′4″ West). This is an area where diverse types of landscape (according to the ELC: urban, peri-urban, rural and natural) can be found and which exceed administrative spatial boundaries Fig. 3. The main topography of the landscape within this study area is composed of natural areas, mainly Mediterranean

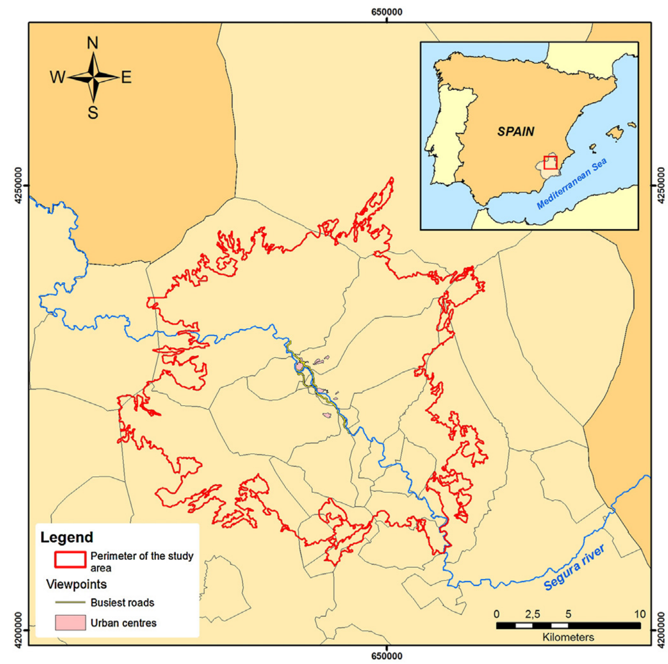


Fig. 3. Location of study area depicted by the red perimeter and viewpoints.

Table 1
Landscape units present in the study area before and after digitizing the traditional orchard (CLC06: 999) which was incorporated into other CLC06 units, especially the complex cultivation patterns (CLC06: 242).

CLC06 Landscape units					
Start			End		
Code	No units	Area (ha)	Code	No units	Area (ha)
111	14	1082.41	111	14	1081.92
112	1	29.08	112	1	29.08
121	11	674.33	121	11	674.33
122	1	40.68	122	1	40.68
131	3	105.61	131	3	105.61
133	3	82.16	133	3	82.16
211	18	10482.42	211	18	10482.42
212	3	264.07	212	3	264.07
221	6	380.33	221	6	380.33
222	22	32223.30	222	22	31006.62
223	1	30.79	223	1	30.79
242	**26**	**8337.46**	**242**	**26**	**5716.51**
243	29	8573.02	243	29	8573.02
311	1	78.10	311	1	78.10
312	17	11187.44	312	17	11187.01
321	1	95.39	321	1	95.39
323	31	12195.17	323	31	12187.31
324	30	5011.27	324	30	5010.02
331	2	104.16	331	2	104.16
333	27	5214.82	333	27	5214.82
512	5	165.84	512	5	164.73
			999	25	3848.77

forest located on the more inaccessible slopes or protected by management ordinance. This area is also culturally and historically important where agriculture has played a major role, specifically traditional orchards, in the immediate surrounding area of the Segura River. In fact, these orchards were the result of the Ricote Valley being the last Muslim stronghold on the Iberian Peninsula up until 1614. Specifically, these types of landscape units associated with traditional agriculture had to be reclassified from photographic interpretation and separated from the units which are integrated in the CLC06. To differentiate this cultural element so characteristic of the Mediterranean region (Mata and Fernández, 2004, 2010), we assigned it a new numeric code (999). As a result, a new catalogue of units is obtained as summarized in Table 1.

2.2. Perception-based Survey and DELPHI survey with parameter weighting

For our study, two online surveys were conducted: the first to assess the population's landscape preferences, and the second to obtain the specific weight of each landscape factor from a panel of experts for the proposed landscape analysis.

Several studies conducted by Bishop (1997), Roth (2006) and Wherrett (1999) show that the Internet is an appropriate medium for conducting studies of perception with results similar to face-to-face surveys (Lindhjem and Navrud, 2011). The questionnaire for the population survey presented a set of photographs, and despite its limitations (Daniel, 2001; Palmer and Hoffman, 2001; Steinitz, 2001), was based on the model used in previous studies (e.g., Arriaza et al., 2004; Dramstad et al., 2006; Schirpke et al., 2013; Svobodova et al., 2012) which have demonstrated its value (Barroso et al., 2012; Daniel, 2001; Palmer and Hoffman, 2001; Steinitz, 1990; Zube et al., 1987). The study by Arriaza et al. (2004) was one of the first to evaluate the population's preferences of Mediterranean landscapes, especially rural landscapes. His survey was conducted with 226 people with different educational backgrounds using 160 images from the northern part of the Province of Cordoba (Andalusia, Spain).

In this study, the population survey was made available on the Internet for a period of five months. During this period, a total of 26 images representing different landscape units within the study area were made available and grouped according to their similarities (Fig. 5 shows some images used on the survey). The images were captured on days with high visibility, without any use of special filter, effect or any other digital manipulation that could distort its content (Bishop, 1997; Barroso et al., 2012).

In the survey, participants had to evaluate the Visual quality (Vq) and Visual perceptive fragility (Vpf) of each landscape unit according to their preferences using a 10-point evaluation scale from 1 (not beautiful) to 10 (very beautiful). To avoid technicalities and erroneous understandings, terms of visual quality and perceptive fragility were presented, respectively, as the "level of beauty" and "degree of protection" that each unit deserves. After closing the survey the results were classified and mapped (Brown et al., 1986).

At the same time, an international group of 55 renowned landscape experts participated in a DELPHI survey. In order to ensure the quality of the experts selected for this survey, we checked the number of citations they had received within the last two years in Google Scholar™. The main objective of the DELPHI survey was to assess the individual weight of each factor that effects the Preservability (Pb) of the landscape unit. An evaluation scale from 0 (not impor-

$$Pb_o = \frac{\sum_{i=1}^{n} Q_i + \sum_{i=1}^{n} F_i + \sum_{i=1}^{n} Ve_i}{Sup_i}$$

$$Pb_{o\omega} = \frac{\omega_Q \sum_{i=1}^{n} Q_i + \omega_F \sum_{i=1}^{n} F_i + \omega_{Ve} \sum_{i=1}^{n} Ve_i}{Sup_i}$$

$$Pb_{\omega} = \frac{\omega_Q \sum_{i=1}^{n} Q_i + \omega_F \sum_{i=1}^{n} F_i + \omega_{Ve} \sum_{i=1}^{n} Ve_i + \omega_{Vq} \sum_{i=1}^{n} Vq_i + \omega_{Vpf} \sum_{i=1}^{n} Vpf_i}{Sup_i}$$

Fig. 4. Equations to calculate Preservability using three different methods.

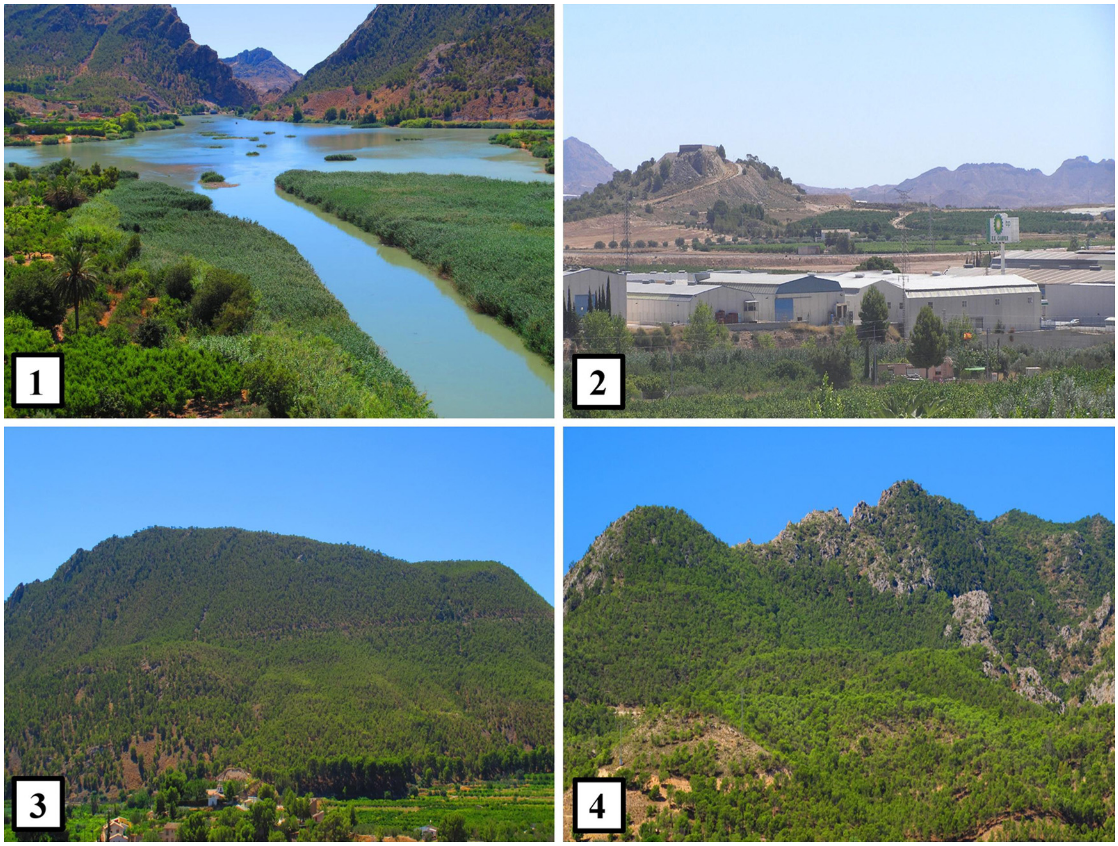


Fig. 5. Photographs used in the perception-based survey with the highest (1) and the lowest (2) score for Visual Quality; and the lowest (2) and the highest (1, 3 and 4) score for Visual Perceived Fragility.

$$v_i = \frac{a_i - \min a_i}{\max a_i - \min a_i}$$

Fig. 6. Formula used to normalize the landscape factors.

tant) to 10 (very important) was used to do this. The results of this survey enabled us to determine the weighting coefficients needed to obtain a valuation function of the Preservability extrapolated to any territorial area.

2.3. Select the landscape attributes

We selected a catalogue of intrinsic attributes (Table 2) based on consulted bibliographical sources and data available at the beginning of the study. These were grouped into three main categories (Otero Pastor et al., 2007) and classified using indicators with different values for Q and F according to the bio-geographic features of the study area.

All the layers obtained for Quality (Q) and Fragility (F) – two for each attribute (except for roads) – were rasterized with a resolution of 25 m × 25 m and subsequently normalized between 0 and 1. The possibility for inaccuracies when using the 25 m resolution (Lee et al., 1999) for natural areas, however, for our study area (>95000 ha), this resolution was suitable.

2.4. Calculate the Preservability

Based on the two major paradigms of landscape evaluation defined by Lothian (1999), the Pb was assessed using three different approaches: objective (Pbo), objective-weighted with DELPHI (Pbow), and finally, objective-weighted and subjective-weighted with DELPHI (Pbw) (Fig. 4).

The *i* corresponds to each of the pixels present in the study area after having differentiated the local land uses in the CLC06, and the ω corresponds to the different weighting for each factor obtained from the DELPHI survey.

The objective of evaluating the Pb concept is to show, using these three methods, the significance of each factor and its effect on the overall results of the Pb. Above all, we wanted to compare the best and worst valued landscape units per model from our survey with the results from previous studies. Furthermore, this approach can also check whether a greater number of factors would offset the possible weaknesses of the original target model Pbo.

3. Results

3.1. Perception survey and DELPHI for valuation of factors

The perception-based population survey received a total of 225 responses (60% men and 40% women). While this survey was available online to the public, it was only advertised to the the Region of Murcia (1472049 inhabitants, Instituto Nacional de Estadística, 2014) through various mediums of communication. Therefore, considering the number of responses and the total size of the universe which the survey focuses on, 1472049 inhabitants, an error margin of 6.67% was incurred for a 95% confidence interval. A considerably small figure which ensures the representativeness of the results.

The results of this public survey show that the groups of landscape units with the highest Vq value (Table 3) are water features

Table 2
Selected landscape attributes with values assigned to quality and fragility respectively.

Category	Landscape attribute	References	Indicators	Quality value(Q)	Fragility value(F)
Physical	Slope	Bosque et al., 1997; Dramstad et al., 2006; Bulut and Yilmaz, 2008; Bishop and Hulse, 1994; Vargues and Loures, 2008; Wu et al., 2006; Otero Pastor et al., 2007	<5%	2	10
			5–15%	4	8
			15–25%	6	6
			25–45%	8	4
			>45%	10	2
	Altitude	Bosque et al., 1997; Brown and Brabyn, 2012	<100 m	2	10
			100–300 m	4	8
			300–600 m	6	6
			600–1000 m	8	4
			>1000 m	10	2
	Water features	Zube et al., 1974; Bishop and Hulse, 1994; Vargues and Loures, 2008; Dramstad et al., 2006; Bulut and Yilmaz, 2008; Arriaza et al., 2004; Wu et al., 2006 ; Otero Pastor et al., 2007	Streams	2	2
			Ramblas	4	4
			Rivers	6	6
			Dams and reservoirs	8	8
			Sea	10	10
	Land use	Dramstad et al., 2006; Bishop and Hulse, 1994; Lee et al., 1999; Otero Pastor et al., 2007	Artificial space	2	2
			Erosion	4	4
			Agricultural	6	6
			Natural/cultural transition	8	8
			Natural vegetation	10	10
Biotic	Vegetation	Gómez-Limón and de Lucio, 1999; Misgav, 2000; Dramstad et al., 2006; Purcell and Lamb, 1998; Bulut and Yilmaz, 2008; Arriaza et al., 2004; Bishop and Hulse, 1994; Wu et al., 2006; Otero Pastor et al., 2007	Sparse or none	2	2
			Degraded	4	4
			Agriculture	6	6
			Natural/agriculture transition	8	8
			Natural vegetation	10	10
	Agriculture	Strumse, 1996; Kaltenborn and Bjerke, 2002; Arriaza et al., 2004; Otero Pastor et al., 2007	Dry	2	2
			Natural agriculture with natural veg.	4	4
			Irrigated and non-irrigated complex cultivation patterns	6	6
			Fruit trees	8	8
			Traditional fruit orchard	10	10
Human activities	Human concentration	Antrop,2005a; Otero Pastor et al., 2007; Vargues and Loures, 2008; Strumse, 1996	>10.000 hbts	2	2
			5.000–10.000 hbts	4	4
			1.000–5.000 hbts	6	6
			500–1.000 hbts	8	8
			<500 hbts	10	10
	Accessibility	Antrop, 2005; Vargues and Loures, 2008; Bulut and Yilmaz, 2008; Arriaza et al., 2004; Bishop and Hulse, 1994; Purcell et al., 1994; Wu et al., 2006 ; Otero Pastor et al., 2007	Track	–	2
			3° Order	–	4
			2° Order	–	6
			1° Order	–	8
			Dual carriageway/motorway	–	10
	Cultural man-made elements	Bulut and Yilmaz, 2008; Arriaza et al., 2004; Otero Pastor et al., 2007		10	10

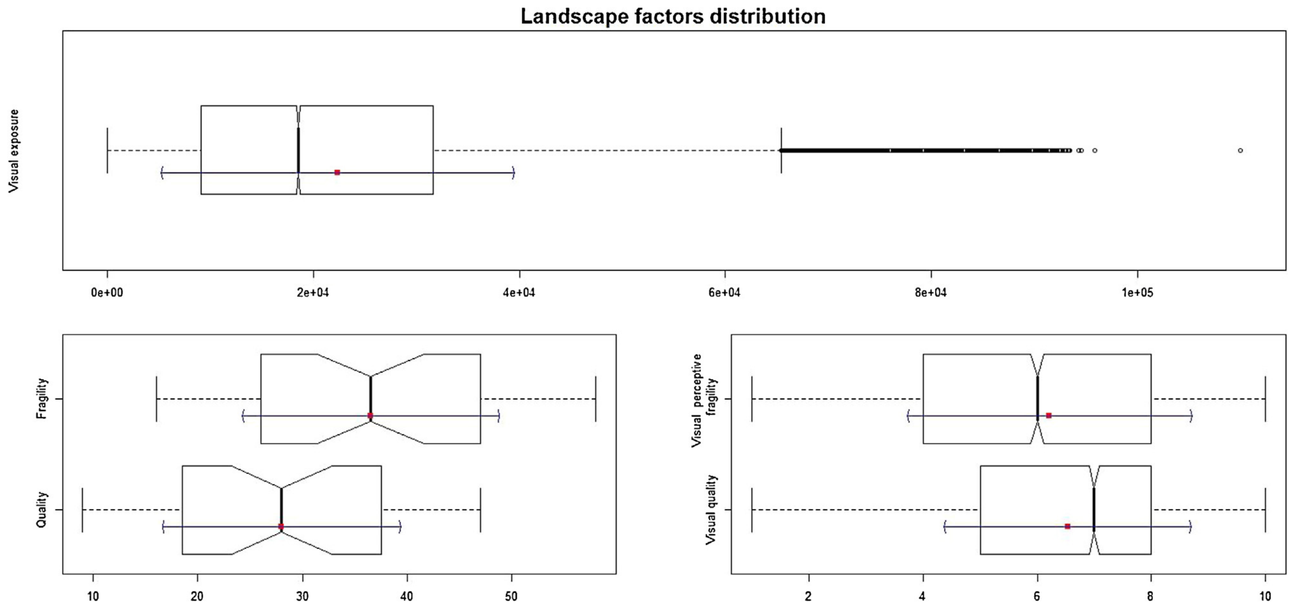


Fig. 7. Boxplot with landscape values for each factor before normalization. Red points depict their average and the blue arrows depict their standard deviation.

Table 3
Landscape unit results from the perception-based survey. In bold landscape units with the highest and lowest Vq and Vpf value.

CLC06 Landscape units		Landscape unit groups	Visual quality				Visual perceptive fragility			
Code	Unit		Mean	Max.	Min.	Sd.	Mean	Max.	Min.	Sd.
111	Continuous urban fabric	Urban fabric	5	7	2	1.10	5	1	7	1.38
112	Discontinuous urban fabric									
121	Industrial or commercial units	Industrial and commercial areas	**3**	**5**	**1**	**1.13**	**3**	**6**	**1**	**1.19**
122	Road and rail networks and associated land									
131	Mineral extraction sites	Expansion zones	4	9	1	2.06	4	9	1	1.97
133	Construction zones									
211	Non-irrigated arable land	Non-irrigated arable land	6	9	3	1.22	5	8	2	1.22
212	Permanently irrigated lands	Crop-growing areas	7	9	5	1.06	6	9	3	1.41
242	Complex cultivation patterns									
221	Vineyards	Fruit trees and berry plantations (non-irrigated and irrigated)	7	10	3	1.26	6	10	3	1.47
222	Fruit trees and berry plantations									
223	Olive groves									
243	Land principally occupied by agriculture, with significant areas of natural vegetation	Land principally occupied by agriculture, with significant areas of natural vegetation	7	9	2	1.14	6	9	4	1.27
311	Broad-leaved Forest	Forests	8	10	7	0.73	**8**	**10**	**5**	**0.96**
312	Coniferous forests									
321	Natural grasslands	Sclerophyllous natural areas	6	9	2	1.52	6	9	2	1.62
323	Sclerophyllous vegetation									
324	Transitional woodland-shrub	Transitional woodland-shrub	7	9	5	0.86	7	10	3	1.43
331	Beaches, dunes, sands	Sparsely vegatated areas	6	9	2	1.29	5	8	2	1.48
333	Sparsely vegatated areas									
512	Water bodies	Water features	**9**	**8**	**10**	**0.69**	**8**	**10**	**6**	**0.76**
999	Traditional orchard	Traditional irrigation-based agriculture	7	10	3	1.41	7	10	2	1.78

Table 4
Experts' score for each landscape factor after the DELPHI survey and after its weighting (results expressed as a percentage of one).

Landscape factor	Delphi weight			Relative weight
	Average	Median	Standard deviation	
Q	0.857	0.9	0.125	1.076
F	0.767	0.8	0.153	0.874
V_e	0.638	0.6	0.196	0.605
V_q	0.700	0.7	0.200	0.731
V_{pf}	0.552	0.6	0.150	0.456

Table 5
Landscape units with highest and lowest Preservability score depending on the method used. CLC Codes: 121: Industrial or commercial units, 312: Coniferous forests, 512: Water features and 999: Traditional orchard.

Method		Landscape units	Preservability value for landscape unit	Basic statistics	
Objective preservability (Pb_o)	Most valued	999	31.704	Max.	31.70
		999	31.255	3rd. Qu	27.35
		999	31.221	Mean	24.08
	Least valued	121	12.490	Median	25.99
		512	12.115	1st. Qu.	22.23
		512	12.091	Min.	12.09
Objective weighted preservability (Pb_{ow})	Most valued	999	27.815	Max.	27.82
		999	27.505	3rd. Qu	24.29
		999	27.313	Mean	21.03
	Least valued	512	9.656	Median	22.88
		512	9.579	1st. Qu.	19.11
		512	9.231	Min.	9.23
Weighted preservability(Pb_w)	Most valued	999	42.472	Max.	42.47
		312	42.435	3rd. Qu	37.67
		312	42.280	Mean	32.13
	Least valued	121	12.785	Median	34.73
		121	12.784	1st. Qu.	28.02
		121	12.616	Min.	12.62

(CLC06: 512), and the lowest Vq value are industrial or commercial areas (CLC06: 121). Regarding the Vpf (Table 3), the group of landscape units most valued were water features (CLC06: 512) and forests (CLC06:311 and 312) and the least valued were the industrial or commercial areas (CLC06: 121). Fig. 5 shows the four best and worst valued photographs as expressed by the respondents in terms of Vq and Vpf.

For the DELPHI survey, we started with a panel of 55 experts. However, only 26 (47%) responded to the first round and 21 (81%) responded to the second round. Of these 21 experts, 4 did not change any of their responses in the second round, indicating a low stability index/rate (5%) and a high degree of analysis and reflection after the first round.

After the average response of the experts had been obtained, we could see that the landscape factors which had the greatest and least influence on the Pb were, respectively, Q (0.857) and Vpf (0.552). Finally, the initial results of the DELPHI survey were weighted (Table 4) according to each factor's importance using the method that most closely represented the perception of each expert (Palacios, 2002).

3.2. Landscape attributes

As the final value of each landscape factor was conditioned by the different attributes that compose it, we found three ranges of different amplitude (Fig. 7). To ensure the factors used a uniform scale in the general formula (Pb), each one was classified between 0 and 1 according to the expression shown in Fig. 6.

Where i corresponds to the number of pixels present in the study area, v_i the normalized value of each factor and a_i the initial value.

In the figure above, we see the objective landscape factors of Quality and Fragility following a normal distribution (Kolmogorov–Smirnov test, $P > 0.05$). For the Visual exposure factor, a significant number of outliers appear that were expected due to the existence of areas of very high visibility. However, this may also be due primarily to the highest outlier due to a computational error in the "accumulative viewshed" calculation. In terms of the subjective parameters, Visual quality (Vq) and Visual perceptive fragility (Vpf), we observed that they were the factors which displayed a wider range of data due to the different scores assigned by the population in the survey. However, the interquartile range of these factors and their confidence intervals are very small.

3.3. The Preservability

The results of each method (Pbo, Pbow, Pbw) demonstrate significant changes in the valuation process (see Table 5). The methods which directly evaluated the intrinsic attributes of the landscape, Pbo and Pbow, prioritized the preservation of the traditional orchard (code: 999) and relegated water features (CLC06: 512) to the bottom of the ranking. These objective-based methods provided the expected results based on the indicators considered for each attribute and the location of each landscape unit.

After including the weighted landscape factors from the results of the DELPHI survey, Pbow, we see minor changes in the score and hierarchy of some units (Table 5), especially industrial or commercial zones (CLC06: 121), which have moved up 3 places from their original position (third from last) to be replaced by water features (CLC06: 512).

These small changes in the ranking of the landscape units demonstrate the loss in equality between the landscape factors, yet significant statistical differences between the results of both methods are still apparent ($P < 0.05$, Mann–Whitney U test).

In the last method, Pbw, where the objective and subjective landscape evaluation paradigms are combined, two particular changes can be seen in the score range: a variation in extremes (especially the higher) and an increase in the interquartile range (Fig. 8). Statistically significant differences were found between the results of this method and the other two previous methods ($P < 0.05$, Kruskal–Wallis H test).

Using the Pbw approach, the traditional orchard (code: 999) remains the landscape unit with a highest score despite not being the most valued unit by the population (Table 3). This result confirms the findings of Kaltenborn and Bjerke (2002), who demonstrated the existence of an inverse relationship between the level of agricultural industrialization and its landscape rating. With respect to units with lower Pb value, the results of the perception-based survey (Table 3) show water features (CLC06: 512) moving higher up the ranking to the second quartile, whereas industrial or commercial areas drop down from the first quartile to the lower Preservability positions.

Finally, the Pb values of each method are cartographically represented by a qualitative distribution divided into quintiles with the same distribution (very high, high, medium, low and very low) (Fig. 9).

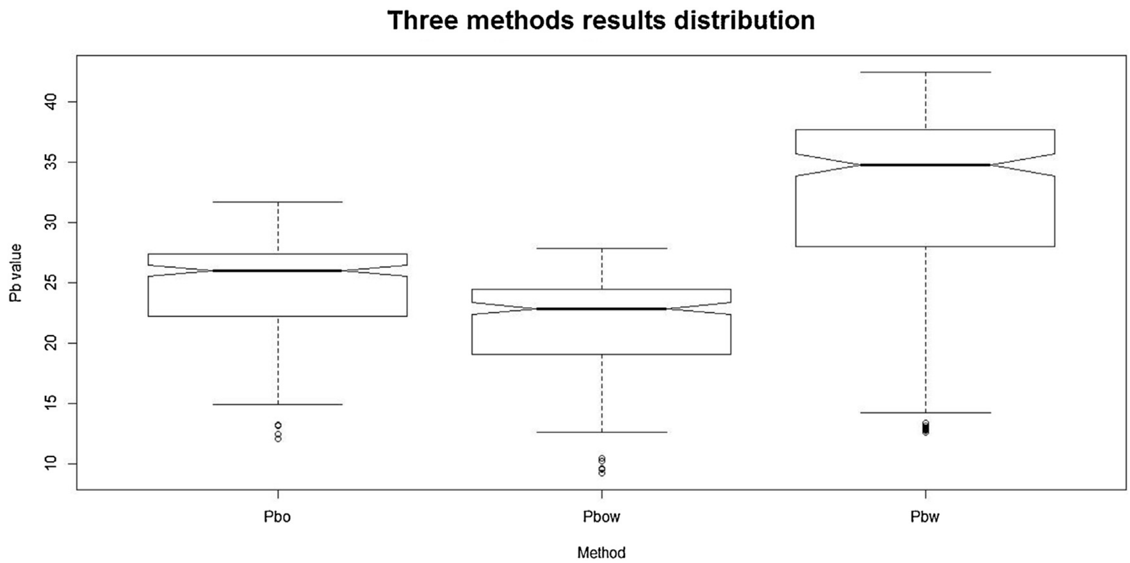


Fig. 8. Comparison of the results of the three methods. Pbw method returns different results than objective (Pbo) and objective-weighted (Pbw).

4. Discussion

4.1. Perception-based survey by the population and DELPHI survey for valuation of factors

The detailed study of the perception-based survey by the population shows that, in accordance with previous papers (Arriaza et al., 2004; Bishop and Hulse, 1994; Brown and Brabyn, 2012; Bulut and Yilmaz, 2008; Kaltenborn and Bjerke, 2002; Wu et al., 2006; Zube et al., 1974, 1982) water features have a positive influence on the visual quality of the landscape. In fact they are the landscape units with the highest score (9/10). On the other hand, the presence of man-made elements leads to negative landscape assessment therefore reducing its visual quality, as pointed out in other studies (Arriaza et al., 2004; Bulut and Yilmaz, 2008; Daniel and Vining, 1983; Wu et al., 2006). As for the visually most fragile units, the population survey shows water features and coniferous forests in mountainous regions to be the most susceptible areas to degradation (8/10). Therefore, they deserve a greater level of protection. The studies of Brown and Brabyn (2012), Misgav (2000) and Svobodova et al. (2012) show similar results regarding the positive valuation of forests, transforming them into areas of high visual fragility. Furthermore, although Tveit et al. (2006) suggests the nonlinearity between naturalness and preference, in our study the highest scores for V_q and Vpf are given to landscape units with a high degree of naturalness and low complexity (Ode and Miller, 2011), thus demonstrating the positive emotional response people give to these types of landscape (Ulrich, 1979).

Regarding the DELPHI survey, despite the ELC definition of landscape being an undeniably perceptual concept, the responses of the experts consulted provides evidence of a greater preference to evaluate the landscape on the basis of its intrinsic rather than its extrinsic attributes. Nevertheless, the Pbw value shows more consistent results that correct the underestimations which are evident in the objective methods. This emphasizes the need to consider the general public's opinion for landscape evaluation studies in order to obtain a more accurate assessment.

4.2. On the method and landscape attribute selection process

As for the method of calculation, we have highlighted a number of weaknesses that must be considered in future studies.

Firstly, despite the many advantages of CLC as a method to evaluate landscape, Gulinck et al. (2001) indicates that it should not be overused. In our case, the continued use of the CLC06 and the existence of attributes with almost identical references (especially use of soil, vegetation and agriculture) causes an imbalance in the representation of the data. This lack of impartiality of attributes, together with the existence of mutually exclusive categories (e.g., water features) are aspects that need to be improved. In addition, the spatial resolution of the CLC06 should be considered as a determinant for delimiting the landscape units, especially at the local scale.

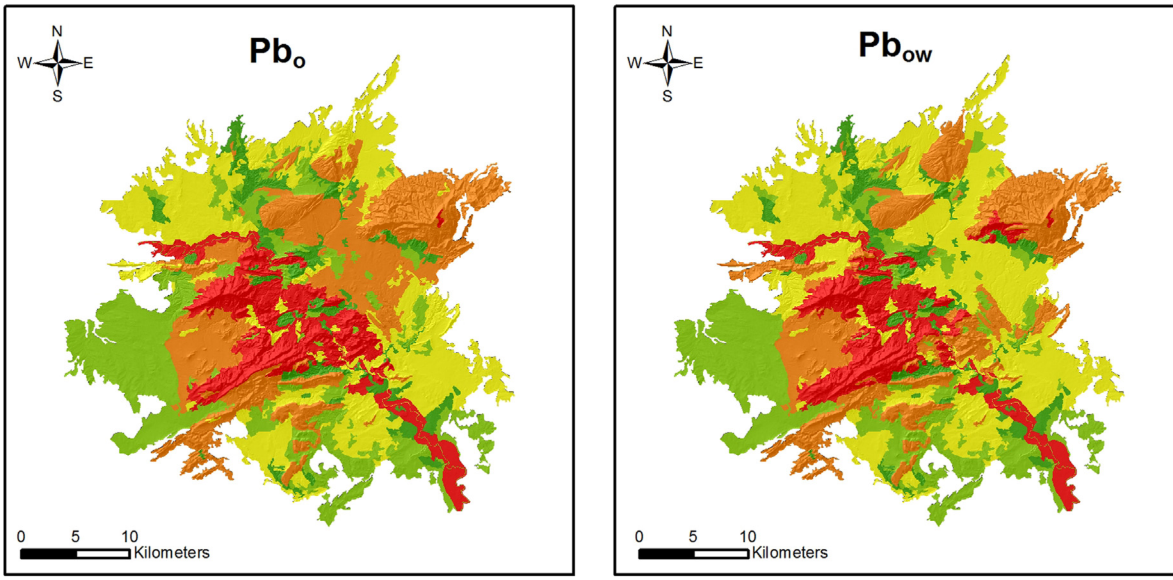
On the other hand, improvements are required concerning the selection of the objectives attributes that define the intrinsic factors of the landscape (Williams et al., 2007), as well as the quality of the data that the catalogue is composed of (Antrop and Van Eetvelde, 2000). Due to the dataís influence on the final Pb value, the degree of subjectivity and the inaccurate data for the landscape attributes should be reduced to a minimum during the selection process. In this case, depending on the environmental and/or anthropic characteristics of the study area, it is recommended to select the more robust attributes – e.g., from official sources like CLC –, which describe the landscape as accurately and fully as possible.

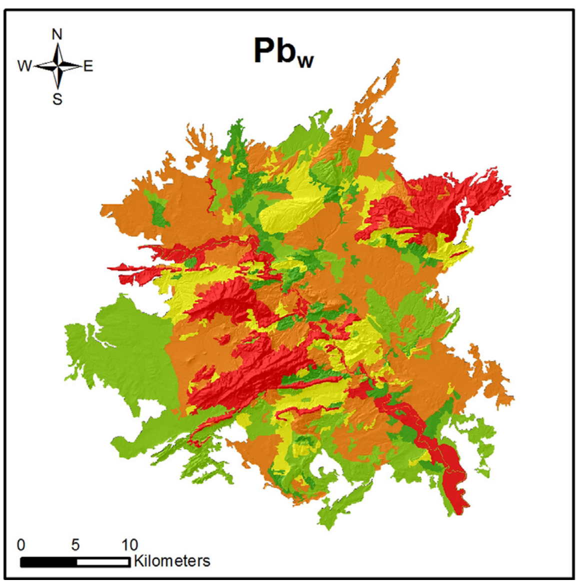
As well as the easily measurable attributes, there exist a number of perceptual (Palmer and Hoffman, 2001) and objective attributes (Daniel, 2001) which are rarely included in landscape assessment when using photographs. In the present study, objective and subjective factors have omitted attributes difficult to assess or capture from images such as sounds, smells or fauna that other studies have included (e.g., Brown and Brabyn, 2012; Otero Pastor et al., 2007).

Finally, due to the spatial resolution of the study (25 m × 25 m) some linear elements (e.g., ramblas, rivers, streams or roads) are difficult to represent (Brown and Brabyn, 2012) and their size tends to be overestimated, especially when we consider the intermittent Mediterranean watercourses.

4.3. Preservability

Statistically significant differences between the results of the three methods ($P > 0.05$, Kruskal–Wallis H test) show the importance of the Pb expression which possess the weight of each factor and the population's perception. The contribution of these components, especially the population's perception, has corrected the





		METHOD*		
Preservability		Pb_o	Pb_{ow}	Pb_w
	Very high	14.103,34	13.304,35	17.311,25
	High	26.684,13	22.679,99	35.235,89
	Medium	27.162,09	33.061,35	12.374,66
	Low	21.542,06	20.374,11	24.397,38
	Very low	6.866,26	6.938,09	7.038,70

* Data expressed in ha.

Fig. 9. Cartographic representation of the different thresholds for each of Pb methods. The table shows the area expressed in hectares. The study area is within each value of Pb.

results obtained in the exclusively objective perspectives of landscape (Pbo and Pbow), making them more consistent with the preferences of the public, Pbw.

The combined and weighted approximation between the objective and subjective approaches used within the Pbw method, has yielded a procedure of landscape evaluation easily reproducible with similar results to those obtained in other studies of perception-based public surveys (e.g., results Arriaza et al., 2004.; Brown and Brabyn, 2012; Bulut and Yilmaz, 2008; Kaltenborn and Bjerke, 2002; Sevenant and Antrop, 2010; Svobodova, 2012; Wu et al., 2006). However, due to the methodology's peculiarities and local uses of the study area, there may be a slight discrepancy in terms of the hierarchy of the various landscape units, as the landscape factors considered include cultural and territorial aspects which makes our methodology more complete compared to the subjectivity reflected by other surveys. Also, the versatility of the Pbw model allows you to apply it to other regions. However, the highest level of subjectivity of the method lies in the adaptation of each landscape attribute range to the bio-geographic characteristics of the study area.

To check the reliability and sensitivity of the method to detect areas with a high landscape value, it was used within areas which are protected by European (SAC, SPA) and/or national (Protected Natural Areas, PNA) legislation. We found that an average of 77% of the rated surface area within the higher Pb thresholds, "Very High" and "High", already had some level of protection according to the Pbw method. In spite of no statistically significant differences ($P > 0.05$, two-way ANOVA) between areas inserted in higher Pb thresholds for each method, a comparison showed that the results of the Pbw method are mainly within the "Very high" threshold whereas the results of the other methods fall within the "High" threshold.

Conversely, statistically significant differences were found ($P < 0.05$, ANOVA) between the protected areas within the different Pb thresholds despite the method used. Those classified as "Very high" and "High" Pb units covered more protected hectares than the units with “Very low” and “Medium” Pb. This shows the method’s high capability for detecting protected areas.

5. Conclusions

The process for landscape assessment we have developed using the weighted Preservability (Pbw) concept is a valid method which can be applied and adapted to any territory which allows for different landscape protection criteria to be established. The method is able to compensate for the limitations of the purely subjective and objective landscape approaches producing results that are consistent with the landscape attributes and the perceptual reality of the population. In addition, this holistic model has democratized the process of landscape evaluation in line with the principles of the ELC and help during the landscape assessment and decision making process. By including the participation of the population, the role of the experts has been relegated to advisors who determine the weight of each landscape factor.

Furthermore, the results have also shown that areas with high Pbw values tend to have some degree of environmental protection. This sensitivity allows the extrapolation of the Pbw index and its different Preservability thresholds into future areas which have not been evaluated yet. Also, the cartographic base of the results facilitates the landscape planner’s decisions and involves the various planners responsible for landscape management at local and regional government levels.

Finally, due to the degree of naturalness within the study area and considering previous studies, the results of the population survey were expected. A notable aspect in the results is represented by the traditional orchard which improves the landscape despite the constant changes to its use. This type of local landscape unit, which the local population value highly and identify strongly with, contains a twofold value which contributes to the landscape: environmental, due to its bio-geographic characteristics and perceptual, due to its cultural, historical and ethnographic value.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.landusepol.2015.11.004.

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