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Understanding socio-spatial perceptions and Badlands ecosystem services valuation. Is there any welfare in soil erosion?

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A R T I C L E I N F O

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A B S T R A C T

Badlands are one of the dryland ecosystems where the absence of the regulating ecosystem service (ES) of erosion control enables the provision of cultural ESs, which include, among others, a singular landscape. The lack of consideration of the social value of these areas, due to their low productive value and low biodiversity, has led to their transformation and disappearance. At the same time, the scientific literature that deals with social preferences for the management of these ecosystems is scarce, despite the need to manage these spaces to face the future adverse effects of climate change. This gap can be reduced by establishing a framework for the socio-economic valuation of the Badlands. Therefore, these paper aims to evaluate the social demand for the implementation of management measures to ensure Badlands protection, using as a case study the Region of Murcia Badlands (SE Spain). To this end, a survey was carried out among a representative sample of households in this region; the willingness to pay (WTP) to protect such singular ecosystems and the factors that influence their valuation were studied, especially the spatial component, analysing in detail the protest behaviour (PB). The results show a strong PB in the population (44.29 % of the sample), with a mean WTP of 15.93 €/household/year. Despite the population's preference for the promotion of regulating ESs in eroded areas in general, cultural ESs are more important in the case of Badlands, positively in terms of WTP and negatively for PB. Spatial factors were found to be of great importance in the valuation, showing the existence of local patterns. These results will help decision-makers to achieve more efficient and socially accepted spatial planning in the management of singular eroded areas.

1. Introduction

Drylands are the largest biome on Earth, representing approximately 40 % of the Earth's land surface (Schimel, 2010; Li et al., 2021). These ecosystems are mainly located in arid and semi-arid regions of the world (Prăvălie, 2016;) where water scarcity and soil erosion limit the provision of ecosystem services (ESs) (Rodríguez-Caballero et al., 2018; Teff-Seker and Orenstein, 2019). ESs are the direct and indirect benefits that ecosystems provide to society and are usually classified in three categories: provisioning (e.g., food and timber production), regulating (e.g., climate regulation and erosion control) and cultural (e.g., recreation and landscape aesthetics), in addition to supporting ESs whose function is to maintain ecosystem processes and enable the provision of other ESs (MEA, 2005; Haines-Young and Potschin, 2018).

Among the different types of drylands are gully and ravine erosion areas, eroded by water flows after a period of intense rainfall (Zgłobicki et al., 2019). The combination of heavy rainfall, sparse vegetation and more or less steep slopes characterises these areas; as a result, they have low levels of provisioning ESs, such as food production, or the absence of regulating ESs, such as erosion control. The lack of erosion control causes soil losses and limits the capacity of these areas for agricultural activity (Yitbarek et al., 2012). When erosion is very intense, it can alter river and floodplain functioning and even lead to siltation and eutrophication of water bodies (Chen et al., 2021). In addition, climate change effects may accentuate soil erosion processes due to an increase in the frequency and intensity of extreme events such as heavy rainfall, increased aridity and/or land use changes (Borrelli et al., 2020).

Gully and ravine erosion can be the result of poor land management. Some studies highlight that reforestation can benefit the recovery of ESs such as timber provision or climate and erosion regulation (Hevia et al.,

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2014; Mongil-Manso et al., 2016). In contrast, other studies suggest that erosion reduction should be avoided when erosion is the cause of high cultural values and/or biodiversity, as in the case of Badlands (Zgłobicki et al., 2018). In these spaces, the absence of the erosion control ES leads to the formation of an ecosystem that specifically offers singular cultural ESs related to landscape aesthetics, recreation or environmental education, among others (Palacio-Prieto et al., 2016).

Badlands are highly eroded ecosystems with poorly consolidated sediments, sparse vegetation and intense drainage (Nadal-Romero and García-Ruiz, 2018). These ecosystems are the result of physical and climatic factors, and, in some cases, human activity, resulting in a diversity of forms and landscapes, depending on the region in which they are located (Zgłobicki et al., 2019). Badlands are mainly located in areas with strong contrasts between wet and dry seasons, such as Mediterranean and subtropical regions (García-Ruiz et al., 2013). In the Mediterranean basin, Badlands can be observed in areas of Spain (Southeast and Pyrenees regions), in the Pre-Alps of France, the Apennines of Italy and in different areas of Israel and Morocco. In addition, Badlands can be found in the western part of the USA, Canada, Mexico, South Africa, China and Australia (Nadal-Romero and García-Ruiz, 2018).

A number of these ecosystems have been protected as UNESCO World Heritage sites (e.g., Canada's Dinosaur Provincial Park) (Zgłobicki et al., 2018), National Parks (e.g., Badlands National Park in South Dakota or Bryce Canyon in Utah, USA) (Ashton et al., 2020) or Natural Parks and Protected Landscapes (e.g., Bardenas Reales, Tabernas Desert and Barrancos de Gebas, Spain) (Desir and Marín, 2013; Rodríguez-Caballero et al., 2015; Belmonte-Serrato et al., 2019). The award of protection to Badlands is indicative of the high cultural and natural value that these ecosystems may possess (Zgłobicki et al., 2018). However, the population's lack of awareness, the feeling of remoteness and/or the lack of interest of the administrations in "non-productive lands" have led to great anthropic pressure on many of these ecosystems (Belmonte-Serrato et al., 2019). This pressure includes mining activities, motor sports activities, land levelling for agricultural expansion, urbanisation, inadequate forestation, military practices and waste dumping (Oleagordia Montana et al., 2016; Martínez-Hernández et al., 2017; Martínez-Valderrama et al., 2020). In this sense, management measures to protect Badlands always include those aimed at limiting, halting or even reversing these pressures and their effects (Lugeri and Farabollini, 2018).

Badlands protection and management makes it possible to improve/increase the provision of certain ESs, mainly cultural, which provide a social benefit that is not exchanged in a market (Perni and Martínez-Paz, 2017). To estimate the social benefit, economic valuation techniques of non-market goods are used, such as the contingent valuation method, for the population's willingness to pay (WTP) for the protection and implementation of management measures, with the value obtained being a proxy of the expected socio-economic benefits (Martínez-Paz et al., 2019). Although there is abundant literature on Badlands from a wide variety of disciplines, studies on the physical analysis of these ecosystems and the erosion-vegetation relationship are particularly extensive (Aucelli et al., 2016; Saha et al., 2021). In this regard, there are hardly any studies that have evaluated the benefits of these ecosystems from a socio-economic perspective (García-Llorente et al., 2012), although such studies are more frequent in other types of dryland ecosystem, such as deserts (Eslamian et al., 2016; Schild et al., 2018).

In the economic valuation of environmental assets, one part of the population may value the good/service in question positively, while rejecting the economic valuation exercise or its instrumentalisation (Meyerhoff et al., 2014). These individuals will declare that they are unwilling to contribute (so-called protest responses), when in fact they do value the asset (Chen and Qi, 2018). Analysis of the protest behaviour (PB) of the population can help us to better understand and evaluate population preferences in ecosystem management (Lo and Jim, 2015).

Contingent valuation exercises permit the identification of factors influencing the WTP and PB of populations. While socio-economic factors are frequently analysed, the study of the influence of factors related to the spatial dimension or to the valuation of different types of ES is much less common (Söderberg and Barton, 2014; Martínez-Paz et al., 2021; Albaladejo-García et al., 2021) despite the direct and indirect benefits that people derive from ESs (Perni et al., 2020) and the influence that local spatial patterns have on the perception of these benefits (Johnston et al., 2015; Martínez-Paz et al., 2021). In these spatial patterns, it is not only the clustering or dispersion of values that has to be taken into account, but also the fact that there is no specific spatial pattern.

Thus, the socio-economic valuation studies found in the literature usually apply contingent valuation in a particular study area, ignoring the analysis of WTP and PB together with ES preferences and spatial aspects of social demand. Therefore, the question arises as to what kind of spatial and ESs factors influence will have on the demand analysis (WTP and PB). The hypothesis to be tested is that there is a positive valuation for a dryland ecosystem that has so far hardly been studied from a socio-economic point of view.

In this context, the main objective of this work is to study the social demand for Badlands, evaluating the WTP and PB and analysing the factors that determine them, with emphasis on the spatial dimension impact and ESs valuation. For this purpose, the Badlands of the Region of Murcia (SE Spain) were selected as a case study, an understudied dryland ecosystem. Here, the expansion of agriculture and motorised activities, among other factors, threatens the conservation status of these ecosystems, which are part of the cultural and landscape identity of this semi-arid Mediterranean region. These threats are not only exclusive to the Badlands of the Region of Murcia, but can also be observed in other ecosystems with these characteristics, such as in Tabernas Desert and Bardenas Reales (Spain), Chambal Badlands (India), Calanchi Badlands (Italy) and in the Painted Desert (Australia) (Zgłobicki et al., 2018), which means that the case study has a scope that exceeds its local relevance.

The contribution of this work to the literature is two-fold: (I) it estimates the socio-economic benefits of one of the least studied drylands ecosystems (Badlands) from the environmental economics perspective, and (II) it analyses the influence of, among other factors, spatial and ES valuation factors in eroded areas, regarding both the PB and WTP, highlighting the importance of considering these aspects in this type of study. In this sense, this work is a contribution to the development of the existing literature on social valuation and drylands ecosystems management. These are very important aspects in the current climate change political context and should lead to an increase interest in public plans and projects for this type of space (Borrelli et al., 2020). Thus, the main novelty of this research deals with considering a broader implication than traditional socio-economic valuation studies, by providing the public's personal motivations for having a WTP and, in addition to, by considering PB for the protection of the Badlands, addressing therefore the existing literature gap.

2. Materials and methodology

In this section the study area was described, and the statistical techniques used for modelling explained, together with the data collection process employed. A population survey was carried out to determine the social demand for the Badlands and the factors affecting this demand (Fig. 1). To this end, different analytical methods such as Analytic Hierarchy Process (AHP), Contingent Valuation Method (CVM) and Hot and Cold spots analysis have been combined to integrate ecosystem services preferences and spatial aspects into the demand analysis. The survey data collection was analysed using the statistical programme Gretl, while ArcGIS software was used to process the spatial data.

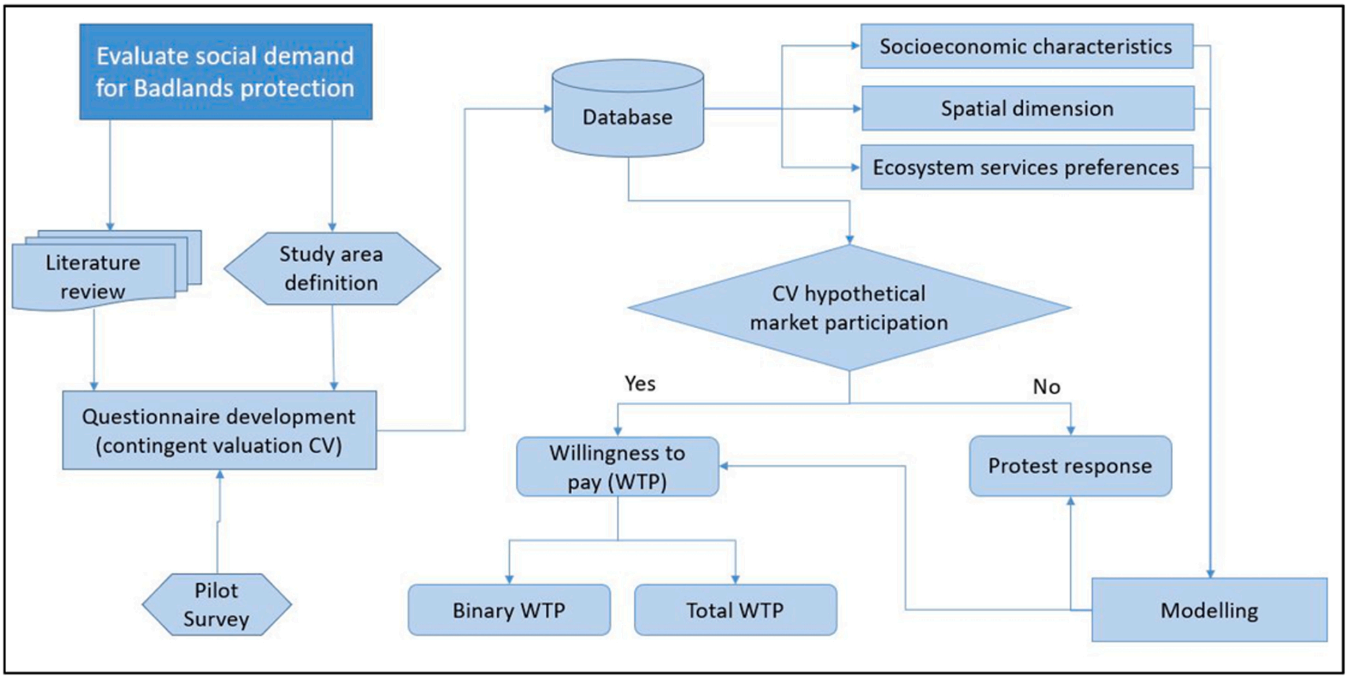

Fig. 1. Methodological process.
Source: own elaboration.

2.1. Study area

Badlands are one of the most representative areas of the Region of Murcia (SE Spain) (Alonso-Sarria et al., 2011). They are ecosystems devoid of vegetation cover, made up of loamy-clay substrates, with a high-density drainage network and intense morphostructural dynamics (Gallart et al., 2013). The marked impermeability and poor cohesion of the substrate, the presence of vegetation cover adapted to water scarcity areas, the more or less steep slopes and, above all, the scarce but intense rainfall characteristic of the region are factors responsible for the great erosive action (>50 tonnes/ha/year) that gives rise to these ecosystems (Romero-Díaz et al., 2020).

Thus, the development of these singular areas is due to typical fluvial processes as well as mass movements, gravitational displacements and subsurface erosion or piping (Romero-Díaz et al., 2020). Five Badlands ecosystems have been identified in the Region of Murcia (Fig. 2): Cuenca Abanilla-Fortuna, Cuenca de Mula, Barrancos de Gebas, Rambla de Librilla/Barranco del Infierno and Paisaje Lunar and Rambla el Garruchal. These Badlands were identified through a combination of geographic information systems analysis and literature review.

The Badlands are located in the central-eastern part of the Region of Murcia, occupying an area of approximately 8200 ha, where ravines, gullies and piping processes are present. Angular morphologies predominate, with the exception of areas in Cuenca Abanilla, where rounded shapes are present. These geological and landscape characteristics constitute one of the features of these ecosystems' identity that have allowed them to be declared protected areas, as is the case of the Barrancos de Gebas Protected Landscape, where there is national and even international interest in its use for scientific, educational and tourism purposes (Belmonte-Serrato et al., 2019).

For most of these Badlands, anthropic pressure has reduced their extension and worsened their conservation status. Of these areas, three are threatened by agricultural development, the exceptions being Barrancos de Gebas, which has a regional protection status, and Rambla de Librilla/Barranco del Infierno, due to its poor accessibility. Urban activity also represents a threat, mainly in areas close to communication routes such as Cuenca de Mula and Abanilla-Fortuna. Furthermore, these areas are frequently used as rubbish dumps. Unsuccessful forestation in the five Badlands under study may also be because of their degradation. Finally, given the misinformation and lack of surveillance for many of these ecosystems, which are not very visible to the majority of the population, they have been subject to an unfavourable social perception (Belmonte-Serrato et al., 2019).

2.2. Methods

The central methodology of this work was Contingent Valuation Method (CVM) (Hoyos and Mariel, 2010). CVM is a stated preference method in which the respondents are directly asked to express their WTP for the improvement or conservation of goods or services that lack a real market. Through the creation of a hypothetical market, the monetary value of an environmental asset and the estimation of the Total Economic Value (TEV) – which includes use and non-use values and, consequently, the benefits derived from the implementation of the management measures – are obtained (Martínez-Paz et al., 2019).

In addition to CVM, social participation techniques were applied using decimal Likert scales and pairwise comparison. For the pairwise comparison, the Analytic Hierarchy Process (AHP) technique (Saaty, 1980) was used to evaluate the relative importance given by the population to the promotion of the three main types of ESs (provisioning, regulating and cultural) in eroded areas. With this technique, the respondents prioritise the elements they are comparing, obtaining the relative importance of each of them. A Saaty scale from 1 to 9 was used, where a value of 9 represents the highest relative importance for the respondents of a given element with respect to the one being compared, while a value of 1 indicates the same relative importance for both (Koschke et al., 2012). This method also makes it possible to obtain a measure of the respondent's consistency in their evaluations, given the redundancy of the comparisons made, with the so-called Consistency Ratio (CR) (Saaty, 1980). The consistency study is especially useful when evaluating elements with which the respondents are not familiar, as may be the case with the ES concept, allowing contradictory responses to be eliminated from the analysis based on the redundancy of the information obtained (Koschke et al., 2012). The CR takes values

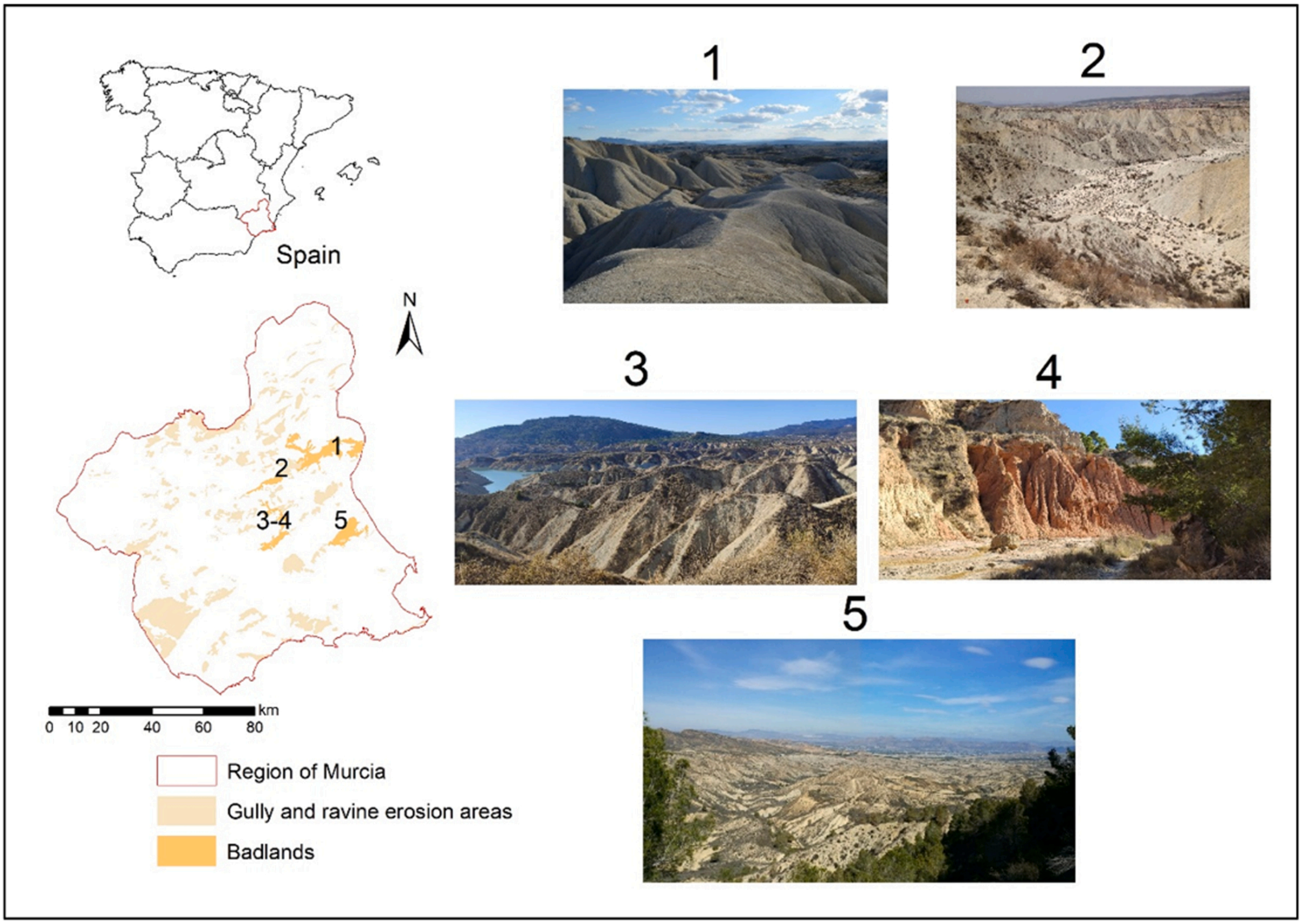

Fig. 2. Region of Murcia Badlands (1 = Cuenca Abanilla-Fortuna; 2 = Cuenca de Mula; 3 = Barrancos de Gebas; 4 = Rambla de Librilla/Barranco del Infierno; 5 = Paisaje Lunar and Rambla el Garruchal).
Source: own elaboration.

between zero (totally consistent comparisons) and one (totally random comparisons). The CR can reach a maximum of 0.2 in the case of non-expert respondents, which is the criterion used in this work as it is a survey of the general population (Albaladejo-García et al., 2021). Based on the relative importance of the ESs, a preference index is constructed, expressed as the specialisation index of the relative importance of each service for each respondent, using the quotient between the individual and group relative importance (Albaladejo-García et al., 2021).

In addition, multivariate analyses were carried out, by developing models with *logit* and *tobit* specifications (Greene, 1997), to identify the factors that determine the two key CVM elements: the PB and the WTP of the population.

Based on multivariate model estimates, hot and cold spot analysis (Johnston et al., 2015; Li et al., 2022) was conducted to explore the spatial heterogeneity of the three dependent variables analysed: probability of PB, probability of Binary WTP (WTPB) and total WTP (WTPT). Hot (or cold) spots occur when groups of observations of the analysed variable, in a neighbour environment, have high (or low) values relative to the study area, which allows local spatial patterns to be identified (Albaladejo-García et al., 2021). These hot and cold spots were calculated using the Getis-Ord Gi* statistic (Getis and Ord, 2010) with a level of statistical significance (P. value) of < 0.1. Thus, high (low) value observations are identified surrounded by other high (low) value observations, where the difference between the observed values is too large to be the result of a random chance (Johnston and Ramachandran, 2014). As for the spatial level used, in this work the 45 municipalities of the Region of Murcia were considered (Supplementary Fig. 1b), locating the respondents according to the municipality in which they have their main residence.

2.3. Data collection

The primary data were obtained through a structured questionnaire consisting of 25 questions divided into three blocks:

(I) Questions on knowledge of eroded areas, relative importance of agricultural and Badlands soil loss and relative importance of the ESs to be promoted in the eroded areas.
(II) Economic valuation of Badlands.
(III) Evaluation of environmental commitment, socio-demographic variables and spatial perception.

The first block makes it possible to: obtain information on the main environmental problems and landscapes that identify the region; determine the relative importance to people of the erosion phenomenon in relation to soil loss in fertile areas (e.g., agriculture) (SLAA) and singular areas (e.g., Badlands) (SLBA); determine the relative importance given by the respondents to the three types of ES (provisioning, regulation and cultural) that could be promoted in eroded areas; and determine the most effective management measures for Badlands protection.

The second block focuses on the quantification of the WTP for Badlands management and protection and the reasons why the respondents would not be willing to contribute, thus allowing the identification of protest responses in the valuation exercise. The WTPB question was formulated as follows: *Would your household be willing to make an annual contribution to a non-profit association* (e.g.*, a land stewardship association*) *in order to manage and protect the Region of Murcia Badlands?*

Following the question in dichotomous format (WTPB), in case of an affirmative answer from the respondents, they had to state their maximum willingness to pay per year for their household (WTPT). For this purpose, a specific amount of money was proposed to the respondents, using five starting points (5, 10, 20, 30 and 40 €) that were previously defined in the pilot survey and randomly shown among the respondents (Bishop and Heberlein, 2019). Therefore, the design was considered to be symmetrical, well-balanced, giving rise to very modest biases even when the anchoring mechanism is very strong (Veronesi et al., 2011). The respondents had to state whether or not they would be willing to pay this amount. Whether the answer was yes or no, the respondents had to state the maximum amount they would be willing to pay for Badlands protection by using an open-ended question. In the case of WTP= 0 in the WTPB question, the motivations expressed by the individuals were identified, categorising them into protests and non-protests.

The last section of the questionnaire included a series of questions to construct variables related to environmental commitment, socio-demographic characterisation and spatial perception. The information on environmental commitment was used to construct three environmental commitment indices (ECI) that, respectively, represent each individual's affective, verbal and real commitment to the environment (AECI, VECI and RECI) (Alcon et al., 2019). These indices were quantified using a Likert scale from 1 to 5, rating the answers given to a series of statements in the questionnaire. Spatial perception was geo-referenced to the postcode of each respondent́s residence. Real remoteness (RREM) was estimated from the distance, in km, from the centroid of each postcode to the nearest Badlands (Supplementary Fig. 1a). Perceived remoteness (PREM) was also obtained, based on what the respondents believed was their remoteness from the nearest Badlands. The difference between RREM and PREM gives rise to a new variable (DREM) that measures the perceived remoteness of the population from Badlands.

Following a pilot survey of 30 respondents carried out in November 2020, the final survey was conducted in person during December 2020, for a random sample of the Region of Murcia's 532,820 households. Samples should be drawn from consistent structures with populations whose values are estimated, and respondents should be randomly selected. The sample of this work was carried out in public places, usually visited by all inhabitants of the Region of Murcia (municipal offices, government offices, universities, etc.), by using proportional quotes of basic socio-demographic characteristics such as age, income (as stated in the supplementary file) and the spatial distribution according to the postal code were aimed. Differences between sample and population characteristics were tested and no differences were found between the following variables: household size, age, monthly income level, active workers, lower education, secondary education, higher education and gender. Thus, 395 complete surveys were obtained, which, at a 95 % confidence level for a dichotomous variable, resulted in a sampling error of 4.9% for intermediate proportions and 3.0% for extreme proportions (Greene, 1997). Regarding the consistency of the respondents' answers in the AHP on ESs valuation, 106 respondents were found to have a consistency ratio higher than 0.2; hence, inconsistent respondents represented 26.8% of the total respondents, assumable inconsistency rate in this type of studies (Emrouznejad and Marra, 2017). These 106 respondents were removed from the sample for all analyses, resulting in a sample of 289 consistent respondents with a sampling error of 5.8 % for intermediate proportions and 3.5% for extreme proportions, which is acceptable for this type of work (Maler and Vincent, 2005; Perni and Martínez-Paz, 2013). All the variables used in this work are listed in the Supplementary Data section.

3. Results

In this section, the descriptive part of the sample will be presented, showing the general perception that the population has about eroded areas as a whole, with an evaluation of the ESs to be promoted in these areas, and with a more specific analysis of Badlands. This is followed by an analysis of the hypothetical market structure, determining the factors influencing the PB and the WTP for Badlands protection, ending with a spatial patterns study.

3.1. Sample characteristics, knowledge of eroded areas and valuation of the current situation in the Badlands

The complete description of the whole sample can be found in Supplementary Table 1 of the Supplementary Data. The typical respondent is male (52.6 %), aged 39, with university studies (completed or in progress), an active worker and resident in a household of 3.3 persons and with an average household income of 1963 €/month. These mean values do not differ from the population averages (CREM, 2020), which ensures the sample's representativeness and its validity for analysis of and inference about the population.

Of the respondents, 62.28 % are Badlands users (USERS) as they declared that they had visited the Badlands at least once in the previous two years. Among the users, a distinction was made between "active users" (ACUS), those who had actually visited in the previous two years (28.72 %), and those who had simply contemplated these ecosystems without actually carrying out any activity in them (33.56 %), called "passive users" (PASU). The main activities carried out by ACUS were contemplating the landscape (60.24 %), hiking (49.40 %), scientific-educational activities (30.12%) and considering this space as a transit area (26.51 %).

The Environmental Commitment Index (ECI) analysis shows a high affective environmental commitment (AECI) (*I would like that*), followed by a lower verbal commitment (VECI) (*I intend to do*) and a lower rating of real commitment (RECI) (*I do*) (Supplementary Table 2).

The sample characterisation with spatial variables (Supplementary Table 3) shows that the respondents are, on average, at a real remoteness (RREM) of 12.27 km from the nearest Badlands (to their residence); however, they have a much greater perceived remoteness (PREM) of 22.84 km. The mean difference between the real and perceived remoteness (DREM) is 10.50 km, with the respondents underestimating and overestimating remoteness by to approximately 34 km and 49 km, respectively. Using the variable DREM binary (DREMB), a distinction was made between the respondents who overestimated remoteness (OVER) and those who underestimated it (UNDER). The sample tended to overestimate (by 80.97 %) the remoteness of their residence from the nearest Badlands.

The environmental problems that exist in the Region of Murcia (atmospheric pollution, water scarcity, etc.) were rated by the respondents (Supplementary Table 4) on a scale of 0–10. All the problems were rated as important, with an average rating of 7.5, with erosion and soil loss occupying an intermediate position. Furthermore, when the respondents were asked to rate, from 0–10, the landscapes that best identify the Region of Murcia as a whole (Supplementary Table 5), they considered all four cases presented to be representative of the region (score above 5) with landscapes resulting from soil erosion being the least valued, as opposed to the most valued landscape, traditional agriculture. Therefore, the respondents considered eroded landscapes to be less attractive for tourism than other, greener landscapes. Also, with regard to areas with erosion and soil loss, the respondents indicated, in a pairwise comparison, that agricultural soil loss (SLAA) is a much more important phenomenon than Badlands soil loss (SLBA), indicating overall a higher relative importance (56.36 %) (Supplementary Table 1).

The results concerning the preferences for the promotion of each type of ES in eroded areas show a higher relative importance for regulating services (RES) (38 %), followed by cultural services (CES) (32 %)

and provisioning services (PES) (30 %) (Supplementary Table 6). From the values assigned to the ES preferences, preference indices were constructed for each type of ES, which measure the specialisation/deviation of each respondent's preferences from the group mean for each type of ES. Thus, a preference index greater than 1 for a given type of ES indicates that the respondent attaches more importance to its promotion than the population as a whole (Supplementary Table 6). A bivariate analysis relating the ES preference indices and the socio-economic and spatial characteristics of the population revealed several significant associations of interest, which are reported in Supplementary Table 7. These include the preference for cultural services of the respondents who considered SLBA more important than SLAA. In addition, there is a clear preference for the promotion of cultural services when the respondents believe they are closer to the Badlands closest to their residence than is actually the case.

The respondents also rated (on a scale of 0–10) the effectiveness of implementing six management measures that specifically contribute to Badlands protection (Supplementary Table 8). The effectiveness of the set of measures had a notable average rating (7.69) and the ranking of these measures, from most to least effective, was as follows: limiting agricultural expansion into these ecosystems (8.22), prohibiting construction (8.16), prohibiting motorised activities (8.00), promoting socio-environmental values (7.82) and limiting reforestation (6.23).

3.2. Demand analysis

For the analysis of the demand for Badlands protection, the respondents were asked about their willingness to pay (WTP) for the implementation of different management measures. The payment vehicle, selected in the pilot survey, is an annual contribution by the household to a non-profit association (e.g., a land stewardship association).

In the contingent valuation exercise, 34.60% of the sample (100 individuals) showed a WTP> 0, while the remaining 65.40% (189 individuals) would not be willing to pay for the measures (WTP=0) (Supplementary Fig. 2). In the latter group it is necessary to distinguish the respondents who are not really willing to make a contribution because they do not see a need for ecosystem management measures (real zeros) from those whose refusal to pay expresses their rejection of the market proposed in the survey (protest zeros). In this work, protest zeros were excluded from the final analysis to avoid conceptual inconsistencies and WTP underestimation (Barreiro-Hurle et al., 2018).

Among the seven arguments for WTP= 0, the following were considered as protests: "The measures should be financed by the users/inhabitants of the area" and "The improvement and maintenance should be covered by public budgets", the latter being the most frequent argument (67.72 %). This led to the conclusion that 128 of the 189 respondents with a null WTP corresponded to protest zeros, with the remaining 61 being real zeros. The hypothetical market is made up of the respondents with WTP> 0 and real zeros, and is thus finally composed of 161 households (Supplementary Fig. 2).

Table 1 shows the descriptive statistics of the total willingness to pay (WTPT) to protect the Region of Murcia Badlands by financing the proposed management measures. The mean WTPT is 15.93 €/household year, with a maximum of 100 €/household year and a minimum of 0 €/household/year (corresponding to real zeros). Users had a WTPT of 18.18 €/household year, significantly higher than the 12.04 €/household year of non-users. The difference between the two groups (6.14 €/household/year) constitutes the mean WTPT of use. The respondents who underestimated the remoteness of their residence from the nearest Badlands (UNDER) had a significantly higher WTPT (21.64 €/household year) than those who overestimated the remoteness (OVER) (14.28 €/household/year).

Table 1
Descriptive statistics of the willingness to pay (€/household/year) depending on the user category and spatial perception.

Category	n	Mean		St. dev.	Minimum	Maximum
WTPT	161	15.93		20.94	0	100
USERS	102	18.18	a	23.09	0	100
NON-USERS	59	12.04		16.02	0	50
DREMB OVER	125	14.28	b	19.53	0	100
DREMB UNDER	36	21.64		24.68	0	100

Source: survey results. t-test difference: (a) 3.263, (b) 3.507, with a P. value < 0.10 for both.

From the mean individual WTPT it is possible to estimate the aggregate WTPT for the population as a whole (532,820 households), which would be the Total Economic Value (TEV), a proxy for the social benefit (Bateman et al., 2006) derived from the Badlands protection achieved by implementing management measures. This gives a TEV of 8, 487,823 €/year. Taking into account the percentages of users and non-users and the mean WTPT of use and non-use, the TEV for Badlands protection can be broken down into 2,037,500 €/year as the TEV of use and 6,415,153 €/year as the TEV of non-use.

3.3. Multivariate analysis

Factors explaining the market structure and the WTP value for Badlands protection, identified through multivariate analysis, were measured using variables grouped into socio-economic characteristics (Supplementary Table 1), Environmental Commitment Index (ECI) (Supplementary Table 2), spatial perception (Supplementary Table 3) and preference indices of the ecosystem services (ESs) to be promoted in eroded areas (Supplementary Table 6). Of the spatial perception variables, two of the three continuous variables (RREM and DIFREM) were incorporated, with PREM being left as the reference category, given that the three variables are collinear. For the same reason, in the ESs indices, the preference indices of cultural ESs (PIC) and regulating ESs (PIR) were used, with the preference index of provisioning ESs (PIP) acting as the reference category. The interactions of the spatial variables and the preference index of ESs with the socio-economic variables were also included as possible explanatory variables.

Protest behaviour (PB) factors were identified with a *logit* model (Table 2), where PB takes a value of 1 if the individual's response is classified as a protest zero (44.29 %) and 0 if it is a real zero or WTP> 0; that is, if he/she participates in the market (55.71 %). Also, using a *logit* model, the factors influencing the binary willingness to pay (WTPB) to protect Badlands are explained (Table 2), where WTPB takes a value of 1 if the individual shows a WTP> 0 (62.11 %) and 0 if it is a real zero (37.89 %). Both models (Table 2) present a good fit (70.04 % and 73.33 % of Correct Classification - CPC) and show no collinearity problems (VIF < 10).

Table 2 shows that the respondents will be more likely to protest if they have a lower preference for cultural ESs (PIC), a higher preference for regulating ESs (PIR), give greater relative importance to agricultural soil loss (SLAA) versus Badlands soil loss (SLBA) or provide an increased real remoteness (RREM) of their residence from the nearest Badlands. The marginal effect of each variable on the sample mean, shown in Table 2, indicates that the probability of protesting decreases by 21.4 % with a one-unit increase in PIC, decreases by 0.3% if the respondents prioritise SLBA, increases by 19.1 % with a one-unit increase in PIR and increases by 0.5 % for each km of RREM.

In terms of the factors influencing the WTPB for management measures implementation, four variables were found to be significant (Table 2). Given their marginal effects, the probability of WTP> 0 increases by 13.1 % for a one-unit increase in PIC and by 15.3% for each additional point of verbal environmental commitment (VECI). In contrast, a one-unit increase in PIR reduces the probability of paying by 15.5 %, while the remoteness overestimation by the population (DREM) reduces it by 0.7 % per km.

Finally, the total willingness to pay (WTPT) was modelled using a *tobit* specification censored at 0 (Table 3). In this model, six variables

Table 2
Logit estimation of PB and WTPB.

Variables	PB model	PB marginal effects	WTPB model	WTPB marginal effects
Constant	-0.164 (0.439)		-1.521 (0.783) *	
PIC	-0.877 (0.219) ***	-0.214	0.579 (0.283) **	0.131
PIR	0.783 (0.215) ***	0.191	-0.688 (0.334) **	-0.155
SLBA	-0.011 (0.005) **	-0.003	-	
RREM	0.021 (0.013) *	0.005	-	
DREM	-		-0.031 (0.014) **	-0.007
VECI	-		0.678 (0.195) ***	0.153
n	289		161	
Log-likelihood	-165.81		-86.63	
CPC	70.04%		73.33%	
VIF	1.35		1.45	

Source: survey results. *, ** and *** corresponding P. values with 0.1, 0.05 and 0.01 significance levels, respectively.

Table 3
Tobit estimation of WTPT.

Variables	WTPT	WTPT marginal effects
Constant	-27.439 (10.096) ***	
PIC	11.114 (3.475) ***	6.916
PIR	-6.934 (4.175) *	-4.315
DREM	-0.323 (0.161) **	-0.201
ACUS	10.778 (4.591) **	7.020
VECI	5.934 (2.340) **	3.705
GEND	12.441 (4.533) ***	9.020
n	161	
Log-likelihood	-500.76	
Chi-square statistic (p-value)	8.68 (0.013)	
VIF	1.46	

Source: survey results. *, **, *** indicate 0.1, 0.05 and 0.01 significance levels

explain the amount of WTP. There will be a higher economic contribution from respondents if they have a higher preference for cultural ES (PIC), if they are woman and active users (ACUS), and if they have a higher verbal ecological commitment (VECI). In contrast, there will be a lower economic contribution if respondents have higher preference for regulating ES (PIR) and if they overestimate remoteness (DREM). Thus, given the marginal effects evaluated for the sample mean, for each additional unit point of PIC, WTPT increases by 6.9 €/household/year, while it decreases by 4.3 €/household/year for each additional point of PIR. For each km that remoteness is overestimated, WTPT is reduced by 0.20 €/household/year, while being an active user (ACUS) of Badlands increases WTPT by 7.0 €/household/year; for each additional point of VECI, WTPT is increased by 3.7 €/household/year, and being a woman increases it by 9.0 €/household/year.

The probability models also allow simulation of the population' s response to the acceptance of and willingness to pay for the proposed management measures (Supplementary Table 8).

Fig. 3 shows the effect of real remoteness (RREM) on the probability of protest behaviour, Prob (PB), and of the difference between real and perceived remoteness (DREM) on the probability of paying, Prob (WTP>0), at three levels of preference index cultural services (PIC) (minimum, mean and maximum) based on the predictions of the models, after fixing the rest of the independent variables at the sample mean. The probabilities of accepting or protesting against management measures for Badlands protection depend on the respondents' preference for the promotion of cultural ESs in eroded areas.

Prob (PB) increases as the real remoteness with respect to a Badlands increases or the preference for cultural ESs decreases (PIC Min). In the case of Prob (WTP>0), as there is a greater difference between the real and perceived remoteness, this probability will increase if the respondents show a higher preference for cultural ESs (PIC Max) rather than a lower preference (PIC Min). For example, these differences between PIC Max and PIC Min will result in the respondents whose residence is located 20 km from the nearest Badlands having a 65 % higher Prob (PB) when they have a lower preference for cultural ESs. The respondents who under/overestimate remoteness by 10 km will have a 38.1/62.5 % higher Prob (WTP>0) if they give a higher preference to cultural ESs.

3.4. Hot and cold spots analysis

Hot and cold spots analysis, to study the spatial heterogeneity of PB, WTP> 0 and WTPT, was carried out for the 45 municipalities of the Region of Murcia on the basis of the models developed (Tables 2 and 3).

The probability distribution of PB in the municipalities of the study area follows a low-clustered pattern, while the probability of the willingness to pay (WTP>0) and the total WTPT present a highly-clustered pattern (Fig. 4). The Prob (PB) includes a cluster of 19 municipalities with low values (cold spots) and 8 municipalities with high values (hot spots), while the other 18 municipalities do not follow a significant

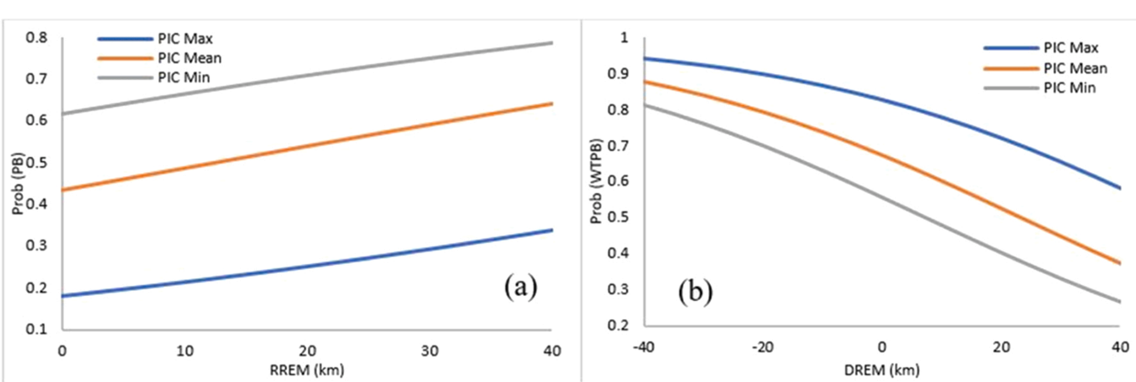

Fig. 3. Relationship of Prob (PB) (a) and Prob (WTP>0) (b) with the preference index of cultural services (PIC) and Differences in Perceived-Real remoteness (Km). Source: survey results.

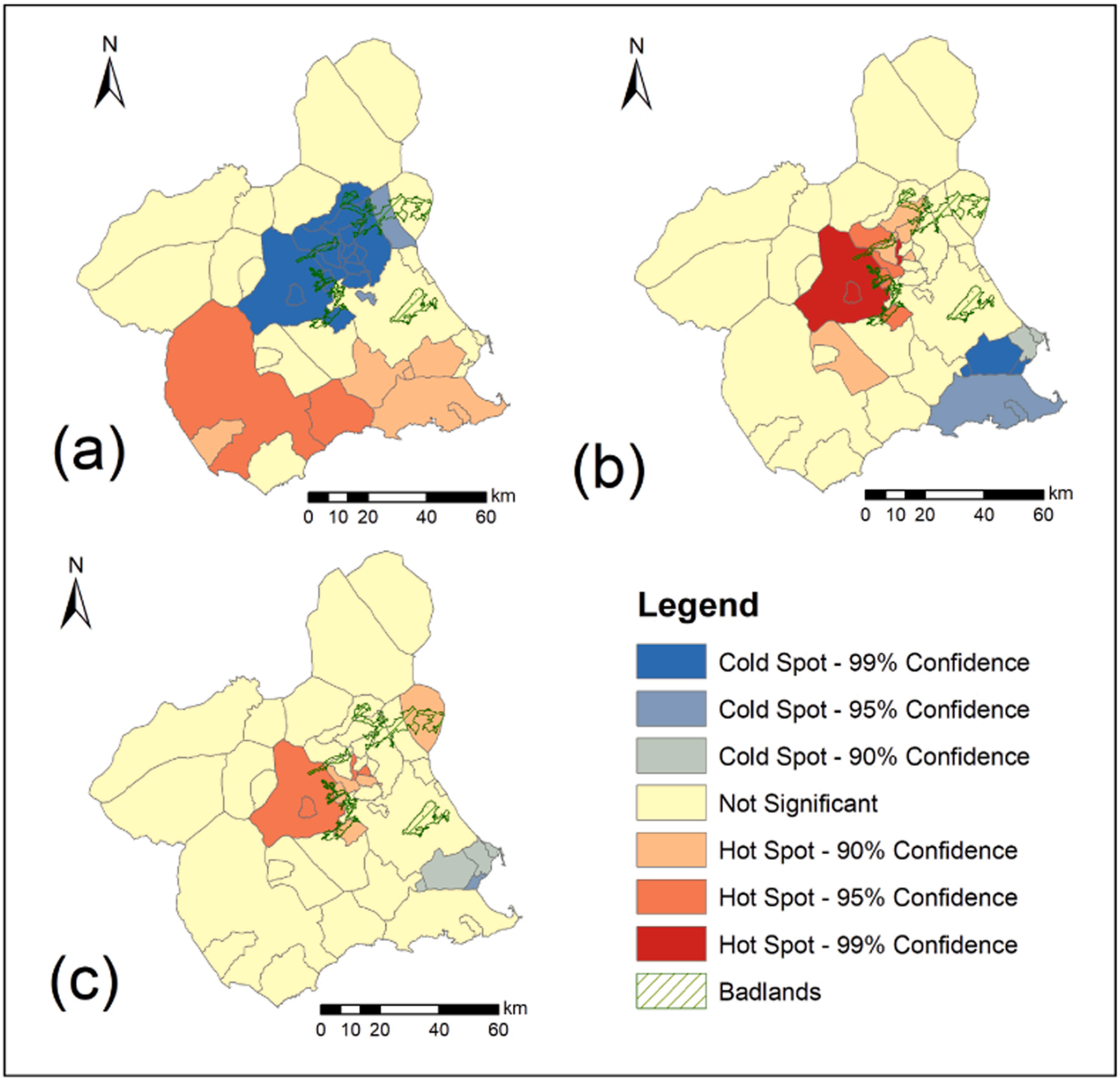

Fig. 4. Getis-Ord Gi* scores of Prob (PB) (a), Prob (WTP>0) (b), WTPT (c).
Source: own elaboration.

spatial pattern (Fig. 4a). Considering the Prob (WTP>0), 12 municipalities are in hot spots, 7 are in cold spots and 26 have no significant spatial pattern (Fig. 4b). Regarding the WTPT, 9 municipalities are clustered in hot spots, 5 in cold spots and 31 have no spatial pattern (Fig. 4c).

Fig. 4 shows that the municipalities with the lowest percentage of protest responses and the highest WTP are clustered around the Badlands. In contrast, away from the Badlands are located clusters of municipalities with higher protest rates and lower WTP.

Once the hot and cold spots had been determined, a characterisation

Table 4
Mean values of variables for prob (PB), prob (WTP>0) and WTPT Hot and Cold spots.

Variables	Prob (PB)		Prob (WTP>0)		WTPT	
	Hot spots	Cold spots	Hot spots	Cold spots	Hot spots	Cold spots
n	8	19	12	7	9	5
Prob (PB)	79.75	18.05***	12.50	64.86***	12.78	56.40***
Prob (WTP>0)	10.38	53.63***	60.42	8.43***	65.67	8.00***
WTPT	4.04	15.70***	16.57	1.92***	19.29	2.68***
PIC	0.74	1.23*	-		1.55	0.79**
PIR	-		-		0.97	1.49*
SLBA	-		60.13	38.73**	65.05	45.94*
VECI	-		3.94	3.23*	3.91	3.19*
RREM	17.15	11.56**	-		8.56	20.48*
ACW	0.61	0.77*	0.78	0.36*	0.74	0.30*
HIK	0.10	0.56*	0.50	0.05*	0.59	0.02**

Source: survey results. *, ** and *** indicate P. value significant at the 0.1, 0.05 and 0.01 levels, respectively.

of each of these clusters was carried out based on variables shown in the Supplementary file (Tables 1, 2, 3 and 6). The Mann-Whitney U-test was used to determine the significant differences (p-value < 0.10) for the three variables analysed for both zones (Table 4).

The results in Table 4, where only significant differences are reported, show higher prob (PB), prob (WTP>0) and WTPT values in hot spots (79.75 %, 60.42 %, 19.29 €/household/year, respectively) than in cold spots (18.05 %, 8.43 %, 2.68 €/household/year, respectively). This confirms the existence of local spatial heterogeneity for the three dependent variables in the multivariate analyses. Among these first three associations, the cluster of municipalities where there is a lower protest probability (prob PB Cold spots) has a higher willingness to pay probability and a higher mean payment amount. On the other hand, in the clusters of municipalities with a higher probability of being willing to pay (prob WTP>0 Hot spots) and a higher mean payment amount (WTPT Hot spots) there is a lower percentage of protest responses.

Table 4 also shows that the clusters of municipalities with a lower probability of protest responses (prob PB Cold spots) and a higher mean willingness to pay (WTPT Hot Spots) occur where there is a population preference for cultural ESs, in contrast to regulating ESs, for which there is a preference in WTPT Cold spots. Thus, citizens located in prob (PB) Cold spots and WTPT Hot spots are linked to high Badlands use values. For these two areas, together with the clusters of municipalities with the highest probability of payment (prob WTP>0 Hot spots), these use values are mainly related to a higher number of citizens that take part in hiking (HIK). Higher values related to active workers (ACW) in the clusters of municipalities with lower prob (PB) and higher prob (WTP>0) and WTPT indicate a higher proportion of active workers, while higher values of VECI and SLBA in the two clusters of higher prob (WTP>0) and WTPT show a greater environmental commitment and a higher relative importance given by the respondents to Badlands. Significant differences can also be seen for the spatial variable RREM, with lower real remoteness in clusters of municipalities with lower prob (PB) and higher WTPT.

4. Discussion

The existence of a social demand for Badlands, one of the dryland ecosystems with the greatest soil loss due to erosion, has been identified, being it similar to the social demand already found from deserts (Eslamian et al., 2016; Andrade et al., 2019). It fills the research gap, which point out the need for demand-side approaches with a spatial perspective for the ESs valuation beyond focusing on the natural system and leaving aside the social system (Burkhard et al., 2014) as indicated by Nicolas-Ruiz et al. (2021). Also, this work complement the research of Vidal-Abarca et al. (2022) who conducted a global review of ESs provision and contributions to human well-being of dry rivers, ecosystems directly linked to Badlands ecosystems in semi-arid areas, highlighting that: "it would be useful to develop research that involves the participation of different social groups through surveys or interviews to demonstrate what ESs really contribute to their wellbeing and how they are valued according to the interests and priorities of each social group" (Vidal-Abarca et al., 2022, pp.14).

The holistic perspective of this study, considering both the supply of ESs and the socio-economic characterisation of its demand, and including the valuation of ecosystem services categories together with a spatial approach, addresses several of the critical aspects identified by Quintas-Soriano et al. (2018a) when identified the state of the art of drylands research.

The positive demand valuation is the opposite of that often reported in the literature on regulating ESs, given that there are numerous reports of the negative valuation given by the population to soil erosion phenomena, especially in agricultural areas (Torres-Miralles et al., 2017; Alcon et al., 2020). When asked about the type of ES to be promoted in eroded areas, the respondents prioritised regulating ESs, in line with the results of Bolaños-Valencia et al. (2019), and, more specifically, gave a high value to the ES erosion control. As Quintas-Soriano et al. (2018b) pointed out, the influence of the socioeconomic and spatial characteristics of the population should always be taken into account in this type of evaluation. In this work there is a positive association between the importance given to soil losses occurring in Badlands and that of cultural ESs. This result is similar to that found by Bidak et al. (2015) when studying desert ecosystems in Egypt, where the promotion of cultural services related to recreational activities was valued, considering provisioning ESs from agriculture as a threat. On the other hand, Olsen et al. (2020) identified a more pronounced effect of distance-decay for cultural ESs than for regulating ESs, a result that is in line with our work showing the negative effect for cultural ESs when remoteness increases.

In this regard, the strong PB of the population (44.29 % of the sample are protests zero) and a mean willingness to pay (WTPT) value of 15.93 €/household/year for management measures to protect the Region of Murcia Badlands, with the non-use component having a higher weight than the use component. The PB and WTPT values differ from those of Martínez-Paz et al., (2019, 2021) and Alcon et al. (2019) for agrarian, fluvial and natural ecosystems, respectively, in the same region, which shown a lower protest response rate and a higher mean WTPT value (Fig. 5). This is confirmed by the valuation of landscapes that identify the Region of Murcia shown in the Supplementary Table 5, where the eroded areas obtain a lower valuation, and therefore a lower social demand for this type of spaces.

In terms of valuation, the results of this work are in line with García-Llorente et al. (2012), where Badlands had the lowest WTPT among a set of Mediterranean ecosystems. They also confirm the results presented by Andrade et al. (2019) regarding the lower social valuation of desert ecosystems in the USA.

When valuing Badlands, an "aridity syndrome" (Easdale and Domptail, 2014) may arise, whereby the inhospitable and desolate characteristics of the space make it difficult for most of the population to show a positive perception of the ecosystem being valued. The inhospitable character of Badlands is one of the reasons that could justify the inaccurate spatial perception that the population has with regard to locating these ecosystems, so that there is a tendency to overestimate the remoteness of their residences.

The sense of place and cultural identity can also influence the valuation of these ecosystems, especially in the case of drylands located in regions with a long agricultural tradition (Faccioli et al., 2020), such as the case study analysed here. The work of Teff-Seker and Orenstein (2019), after evaluating cultural ecosystem services in the desert using the "walking and focusing" method, points out the bias of traditional ES valuation methods in this type of ecosystems, given the peculiarity of their non-material and cultural benefits.

On the other hand, the budget that would have to be allocated annually to implement the management measures evaluated by the respondents of this work could be calculated on the basis of the TEV. A proportional distribution among the three measures that would need clear budgetary support for their implementation shows that the population would be willing to spend more than 3 million €/year to limit the agricultural expansion in these areas, this being one of the management measures most valued by the respondents. The promotion of socio-environmental values or the limitation of afforestation is also associated with a benefit of more than 2 million €/year. These figures should be understood as a monetary average of the social welfare generated by each management measure, resulting in an improvement of cultural ESs provision, to the detriment of regulating and provisioning ESs in Badlands.

In this sense, recent studies (Martínez-Paz et al., 2023) have determined that to maximise well-being, land managers should prioritise land use polices that combines the protection of eroded ecosystems with the maintenance of other regulating ES, such as those from agriculture. In addition, there is a growing number of studies showing the social benefits of protecting natural spaces in arid and semi-arid areas (Ceurvorst and Lamborn, 2018). Therefore, it would be advisable to establish a land

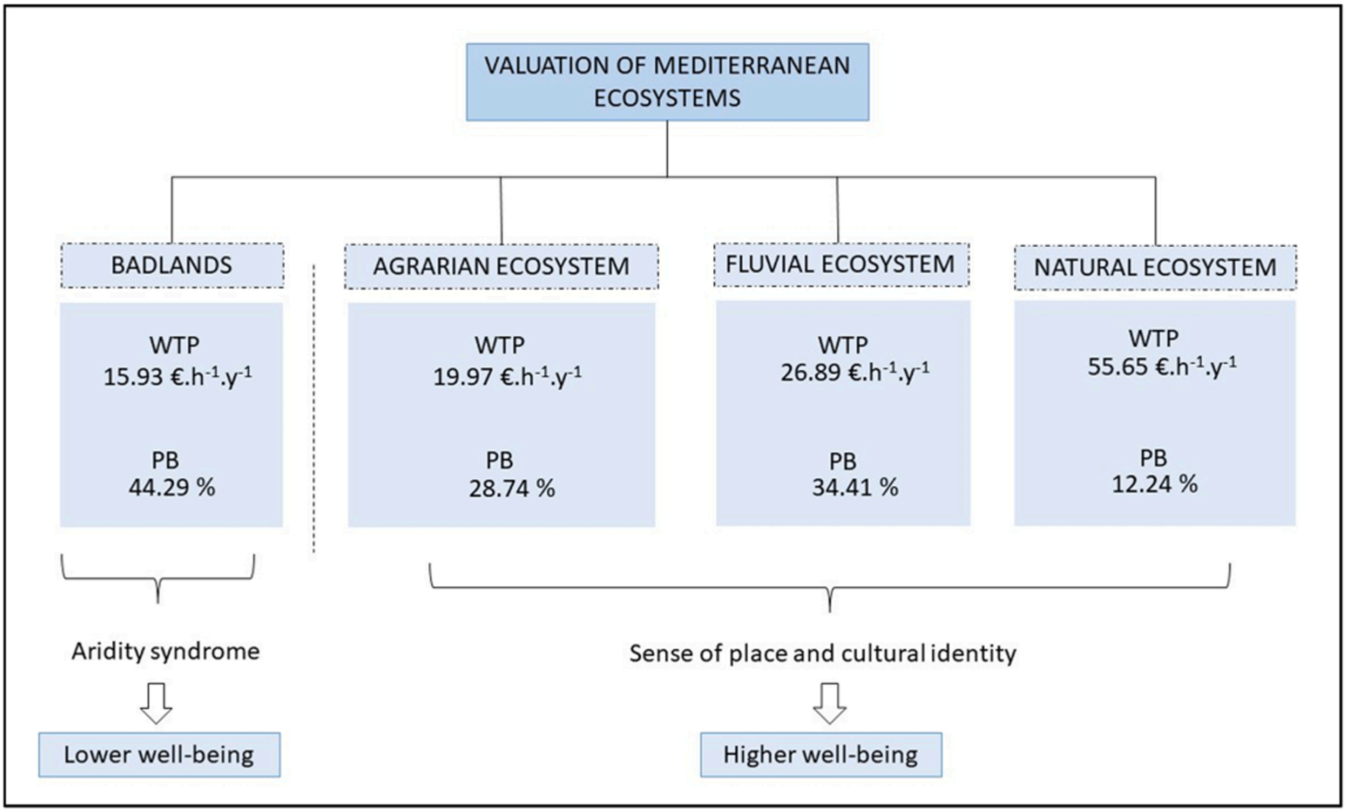

Fig. 5. PB and WTPT values for different Mediterranean ecosystems.
Source: survey results; Martínez-Paz et al. (2019); Martínez-Paz et al. (2021); Alcon et al. (2019).

use policy based on creating perimeter boundaries to protect the Badlands, together with policies aimed to conserve agricultural regulating ES. These management policies can be a reference to be taken into account in line with other eroded ecosystems such as Chambal Badlands (India), Calanchi Badlands (Italy) or the Painted Desert (Australia) (Zgłobicki et al., 2018) in order to enhance the value of the ES provided.

The multivariate modelling results of this work show that the preference indices of ESs and the spatial variables are explanatory factors for PB, WTPB and WTPT. In this sense, significant evidence of the importance of ESs valuation and remoteness in socioeconomic valuation has been found, such that: preferences for cultural and regulating ESs (PIC and PIR, respectively), real remoteness (RREM) and the difference of this variable with respect to respondents' perception of remoteness (DREM) are key in explaining and quantifying the behaviour of the market components of contingent valuation. These results are in line with those obtained in studies such as those of Soga and Gaston (2016) on the increase in negative attitudes towards a natural ecosystem when there is a loss of interaction with that space; Andrade et al. (2019) on the negative effect that remoteness has on the social perception of desert ESs conservation; and Teff-Seker & Orenstein (2019) on the positive effect that cultural ESs, such as spiritual services and recreation, have on people's attitudes towards deserts.

Given that remoteness and ESs valuation modulate the acceptance of and willingness to pay for management measures for Badlands protection, this social acceptability could be improved by promoting the cultural values of these ecosystems through specific environmental education programmes (Otto and Pensini, 2017). Information about the spaces, highlighting their singularity, would reduce the inhospitality and remoteness felt by the population and increase the sense of place regarding this type of dryland ecosystem (Solh et al., 2003).

It should be noted that this work has confirmed the importance of the spatial dimension, identifying local patterns in the distribution of PB and WTP across the territory and spatial clusters of municipalities where these variables take high (Hot spots) and low (Cold spots) values. As in the study of Andrade et al. (2019), it is shown that the greatest social benefits of these spaces are perceived when the population lives close to the dryland ecosystem. The social acceptability and the benefits derived from the management measures implementation are not distributed homogeneously across the region, due to the differences in socioeconomic factors (Quintas-Soriano et al., 2018a), the location with respect to the valued ecosystems (Czajkowski et al., 2017) and the ESs preferences (Albaladejo-García et al., 2021) of the municipalities' populations.

The methodology presented here contributes directly to the assessment of the impacts of reclamation and rehabilitation actions in Badlands, improving the process of Environmental Impact Assessment of specific projects and in the Strategic Environmental Assessment of land-use plans. At the same time, the survey consultation required by the technique used is itself a public participation process, a key aspect of environmental rehabilitation and conservation projects. These processes will help policy makers, managers and beneficiaries to identify changes in the supply and demand of ES needed to meet the future challenges of sustainability and adaptation to global changes (Bruley, 2021).

Based on the above analysis, some recommendations were made that require close attention by the policy makers in developing specific land use policies:

1) Implementation of specific environmental education programmes that increase the population's sense of belonging to the drylands ecosystems, and that can improve their social acceptability.
2) Limit agricultural activity and implement restrictions on urbanisation and motorised activities.
3) Delineate well-conserved areas of Badlands from other agricultural and forest areas, applying differentiated management policies for each ecosystem.

4) Encourage public participation processes when implementing projects, plans, laws, etc., that allow a high level of participation of the affected population in the pursuit of Badlands conservation.

Finally, future research should investigate further social perceptions, psychological and spatial factors of the population that influence the ES perception in Badlands. It would be useful to develop research that involves the participation of different social groups (e.g., group of experts, school children, ecosystem users and stakeholders, among others) according to their preferences for natural ecosystems (greener or drier landscapes), and according to the distance to the study area in order to understand more accurately the social value attributed to the eroded ecosystems. To increase social demand for the Badlands, a greater dissemination of their landscape and cultural values is required, to show both the biophysical processes and the capacity of these ecosystems to provide ES.

In turn, it would be convenient to use some other economic valuation technique to confirm and extend the results obtained, such as a survey of visitors to the eroded areas using the travel cost method, technique that would also allow to confirm the distance effect tested in this work. A parallel line of action should be to disseminate the results, training and collaborating with managers and decision-makers to integrate this ES framework into the day-to-day management of these ecosystems.

5. Conclusions

This study has demonstrated the social demand for management measures implementation to protect the Badlands of SE Spain, especially by limiting agricultural expansion. Thus, the hypothesis established in this work has been fulfilled, with a positive valuation of dryland ecosystems by the population. Despite the population's preference for the promotion of regulating ES in eroded areas is widely known, cultural ESs are more important in the case of Badlands, where there is a higher demand in terms of, higher willingness to pay (WTP) and lower protest behaviour (PB). Therefore, it should be possible to implement a spatial planning and ESs management policy tailored to the different roles of different areas, allowing the coexistence of both.

As for other singular natural spaces, the management measures implemented for Badlands protection are associated with an increase in social welfare, which must also be taken into account by those managing public environmental and land-use planning policies, in order to achieve social acceptance of the measures. Administrations should consider and study the measures that would have the greatest positive impact, among which are the limitation of agricultural activity and restrictions on urbanisation and motorised activities.

Together with Badlands protection, it is also necessary to inform about and promote the cultural and environmental values they provide, increasing society's sense of identification with this type of landscape and promoting its potential as a source of tourism resources and environmental education.

This study informs the need to better understand the social perception of the drylands in the world in order to elaborate the most efficient and socially accepted policy. In this way, it is suggested to promote a land use policy based on the conservation of the landscape and cultural values of the Badlands, as well as a policy to disseminate cultural values provided to society. This type of policies could be applied in other Badlands and eroded ecosystems in the world that are subject to great anthropic pressure and where there are no protection measures already in practice.

Declaration of interest

The authors declare that they have no competing interests.

Data availability

Data will be made available on request.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2023.106607.

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