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Integrating socio-spatial preference heterogeneity into the assessment of the aesthetic quality of a Mediterranean agricultural landscape

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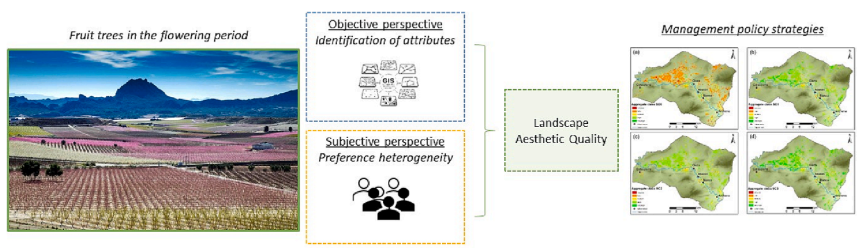
HIGHLIGHTS

- We assess the importance of the aesthetic quality of an agricultural landscape.
- Six attributes of the landscape are valued by the population.
- Three groups of the population are distinguished according to their preferences.
- The aesthetic quality of the landscape has been mapped.
- A diversification landscape policy would increase aesthetic quality levels.

GRAPHICAL ABSTRACT



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ABSTRACT

Assessing ecosystem services associated with agricultural landscapes is of growing interest to the research and policy/practice communities. One particularly challenging aspect to understand is the value of the aesthetic quality of such landscapes, even though this is one of the main contributions that agricultural landscapes make to cultural ecosystem service provision. Indeed, as increasing demands are placed on agricultural landscapes for food production, infrastructure development and urbanisation, aesthetic qualities can be severely affected, particularly if those landscapes are used for traditional agricultural practices. Here we assess the aesthetic quality of an agricultural landscape by integrating social preferences heterogeneity and spatial aspects of the provision, combining subjective and objective perspectives. We work in landscapes dominated by irrigated flowering fruit trees in Cieza, in south-east Spain as it is an excellent example of a semi-arid Mediterranean agroecosystem that delivers multiple ecosystem services, including aesthetic quality, in addition to food production. Using GIS tools and a choice experiment, we assess the social utility function for this landscape, and demonstrate social preferences heterogeneity for demand for the aesthetic qualities of the landscape. Latent class modelling distinguished three populations, with the majority preferring diversified agricultural landscapes and management policies based on a more natural-looking agricultural landscape. These results provide agroecosystem managers with an additional vision focused on enhancing the combination of the most diverse and natural-looking elements in the landscape in order to underpin the delivery of cultural ecosystem services that also increase social well-being.

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1. Introduction

Agriculture is a multifunctional activity that produces goods and services that contribute to the well-being of society. One way of understanding the multiple goods produced can be through the use of the ecosystem services approach, which recognises broad categories of services including provisioning (e.g., food production, fibre, etc.), regulating (e.g., climate regulation, erosion control, etc.), and cultural ecosystem services (e.g., recreational opportunities, landscape aesthetics, etc.) (Haines-Young & Potschin, 2018). Agricultural activity can also result in externalities and disservices that cause well-being loss (pollution, resource depletion, etc.) (Zabala et al., 2021). Despite the importance of cultural ecosystem services, especially for more developed societies (Martínez-Paz et al, 2023), they are infrequently studied (Hermes et al., 2018), apart from certain recreation and tourism services (Nigussie et al., 2021).

Agroecosystems have historically contributed to the high nature value landscapes that have promoted rural development and cultural ecosystem service provision (Plieninger et al., 2019). High nature value agriculture covers around 30% of the European Union's agricultural area, with a large proportion of this in the Mediterranean basin (Lomba et al., 2014). In recent decades, there has been a growing interest in protecting these agricultural landscapes because of the socioeconomic changes (depopulation, economic profitability loss, etc.) (Plieninger et al., 2019). This is the case of the Mediterranean agroecosystems of high nature value, which have degraded their landscape values due to land intensification or abandonment (Martínez-Paz et al, 2019). Thus, these less intensive agricultural systems must be understood and valued if cultural ecosystem services are to continue to be provided (Assandri et al., 2018).

Irrigated agroecosystems located in the semi-arid Mediterranean area present a great variability and complexity of aesthetic values, as a result of prolonged anthropic pressure in a very heterogeneous territory (Barroso et al., 2012). Many of these irrigated agroecosystems, such as traditional irrigated lands, have ceased to be ecosystems primarily dedicated to food production. Thus, they have become spaces suitable for recreational and cultural enjoyment, and therefore, providers of cultural ecosystem services (Martínez-Paz et al., 2019).

The aesthetic quality of landscapes is a cultural ecosystem service that can be defined as the utility or pleasure that people derive from a landscape's appearance (Kalivoda et al., 2014). Several studies show that high aesthetic quality of landscapes contemplation can increase cognitive performance, improve people's mood, foster children's mental and motor development, help mitigate stress and mental fatigue, trigger positive emotions, and promote sports activities and social interactions, among others (Russell et al., 2013; Hartig et al., 2014) and thus very positively affect the health and well-being of the population (Fish et al., 2016). These reasons, among others, led to academics and policy makers have acted for the protection of the aesthetic values of landscape through the European Landscape Convention (Council of Europe, 2000). The aesthetic values of the landscape do not only depend on its physical composition, but also on the subjective value of people, as has been shown in the perception of other European agricultural landscapes (Kalivoda et al., 2014; van Zanten et al., 2016a). Thus, any attempt to design policies for landscape protection must take into account people's subjective perception (Häfner et al., 2018).

Furthermore, aesthetic quality of landscape is an ecosystem service that can influence the provision of other cultural services, such as the presence of leisure and recreational opportunities and the cultural heritage of a territory, both of which are also highly relevant for tourism (La Rosa et al., 2016). Thus, the development of an attractive landscape is especially important for tourist destinations (Stepchenkova & Zhan, 2013). In this sense, one of the challenges for managers and decision makers in rural development is to understand the spatial distribution of those features of any landscape that are considered to be of high aesthetic importance as one way of underpinning the design and development of strategies that effectively manage and disseminate the importance of cultural ecosystem services associated with landscapes (Xiao et al., 2022). Hence, quantifying the aesthetic quality of agricultural landscapes, determining the physical characteristics of their landscape and the population's preferences for their different aesthetic components, is important if we wish to protect agricultural landscapes with the highest aesthetic values, and consider ways to enhance the provision of associated ecosystem services (Aretano et al., 2013; Włodarczyk-Marciniak et al., 2020).

Understanding the aesthetic qualities of landscapes can be carried out using subjective, objective and holistic methods. Many authors (Aretano et al., 2013; Martínez et al., 2016; Molina et al., 2016) recommend applying a holistic approach to quantify the aesthetic quality of landscape considering both the physical characteristics of the landscape (objective perspective) and the population's preferences (subjective perspective). In this sense, Geographic Information Systems (GIS) are an important tool for objective landscape characterization given the large number of components that can be quantified through their use (Hermes et al., 2018). On the other hand, stated preference methods as choice experiments, Q method or contingent ranking method, among others, can be an appropriate way to determine population preferences for different components of a landscape due to their flexibility and ability to consider the multidimensionality of landscapes (Dupras et al., 2018). The use of these techniques also allows one of the principles of the European Landscape Convention to be adhered to, namely that landscape policy measures and actions to be based on people's judgment (de Ayala et al., 2015). Choice experiments, the method used in this work due its suitability to the information obtained regarding the preferences of the population, is particularly appropriate for the individual quantification of the aesthetic quality of landscape components (Tagliafierro et al., 2016).

Social preferences analysis requires the consideration of heterogeneity in preferences (Häfner et al., 2018). Indeed, the assessment of an environmental asset such as landscape, with a high emotional component, reveals very different, if not contradictory, landscape preferences among population groups (Grammatikopoulou et al., 2012). This social preference heterogeneity can be modelled from the information generated in a choice experiment using, for example, latent class (LC) models (Colombo et al., 2009). Despite this, the application of these models in landscape preference analysis has been rare in general (Novikova et al., 2017), and has not thus far been applied to Mediterranean agroecosystems.

In this context, the main objective of this work is to assess the aesthetic quality of the landscape of semi-arid Mediterranean agroecosystems. For this purpose, the irrigated non-citrus fruit trees landscape, one of the most characteristic semi-arid agroecosystems of the Mediterranean area, will be used as a case study, and heterogeneity of social preferences will be addressed. Landscapes during the flowering period of fruit trees will be considered, given that it is at this time when the greatest provision of this cultural ecosystem service takes place (Junge et al., 2015; Schüpbach et al., 2016). The effect on the aesthetic quality of landscape of the implementation of different management policies for these agricultural ecosystems will also be assessed, as well as an exploration of those policies that could maximize the aesthetic quality of landscape. The contribution of this work to the scientific literature is threefold. First, it quantifies the aesthetic quality of landscape by using GIS tools and the choice experiment technique, a rare combination in the literature on ecosystem services assessment. We also assess the social preference heterogeneity in the aesthetic quality of landscape assessment, identifying the sources of such variability, a novel analysis in the case of landscape ecosystem service (Häfner et al., 2018), and finally we spatially localize aesthetic levels of landscape that enhance spatial understanding in the provision of other cultural ecosystem services, such as the presence of leisure and recreational opportunities.

We examine the extent to which aesthetic quality values vary, both between individuals and spatially, to answer the following research questions: (1) Is there a homogeneity of preferences for the aesthetic quality of the agricultural landscape? (2) To what extent does the provision of landscape aesthetic quality change in the presence of different management policies? and (3) How is landscape aesthetic quality distributed spatially?

2. Materials and methods

2.1. Study area

To quantify the aesthetic quality of landscape, one of the most characteristic agricultural landscapes of the semi-arid Mediterranean area was selected, the flowering fruit trees in the Region of Murcia (SE-Spain). The landscape covers 11,915 ha across the municipalities of Calasparra, Cieza, Abarán, Blanca and Archena (Fig. 1). This area comprises 15,139 plots of an average size of 0.787 ha, with a minimum of 0.016 ha and maximum of 50 ha. The landscape is dominated by non-citrus trees. More than 60% of the trees are peach, followed by 20% apricot and 6% plum trees (CREM, 2022). This mix of species generates a landscape that, in spring, is dominated by colourful blossom displays (Guardiola, 2018) that are popular with tourists who flock to the area between February and March. Multiple activities are programmed (guided tours, hiking trails, balloon rides, tourist train routes, etc.) and sports, cultural and gastronomic activities.

Fruit trees are irrigated using water from the Segura River by means of traditional irrigation systems (irrigation ditches, waterwheels, etc.) and it is common to find natural vegetation such as pine forests or riverside vegetation along the banks of the river. The arrival of water from the Tajo-Segura water transfer from 1979 together with the exploitation of groundwater in recent years has led to an intensification of fruit production (Pellicer-Martínez & Martínez-Paz, 2018) that has modified the traditional landscape in some areas with the appearance of modern irrigation infrastructure, such as large ponds, canals, and pumping houses. Agricultural intensification has also been accompanied by urbanization that has led to the landscape being fragmented by new buildings and roads (Guardiola, 2018). All rural and tourism development policies and the CAP policies of the farm-to-fork strategy have a direct impact on the modification of agricultural landscapes. In this study area, the rural development initiative stands out, in which tourism activities directly related to the assessed landscape have an increasing importance and governmental support.

2.2. Methodological approach

The aesthetic quality of landscape assessment carries a high degree of subjectivity, as it depends on the visual characteristics of the landscape (Martínez et al., 2016). For its assessment it is possible to use subjective, objective, and holistic methods. Subjective methods are based on the direct contemplation of the landscape, and the aesthetic quality of landscape emerges as a product of the mind of the landscape observer (Howley, 2011). Objective methods seek to provide an objective assessment of the aesthetic value of the landscape with quantitative results, and the aesthetic quality of landscape is something inherent in the physical landscape (Molina et al., 2016). Holistic methods are based on the combining subjective and objective methods (Bishop & Hulse, 1994). In this work a holistic method (Fig. 2) has been used that combines a descriptive analysis of the aesthetic quality of the landscape (objective perspective) and the assessment of the population's preferences by estimating the utility function (subjective perspective) (Aretano et al., 2013). The objective analysis has been carried out using GIS and the subjective analysis incorporating the population's preferences through a choice experiment. The combination of both methods allowed us to obtain a value for aesthetic quality of landscape by adding the

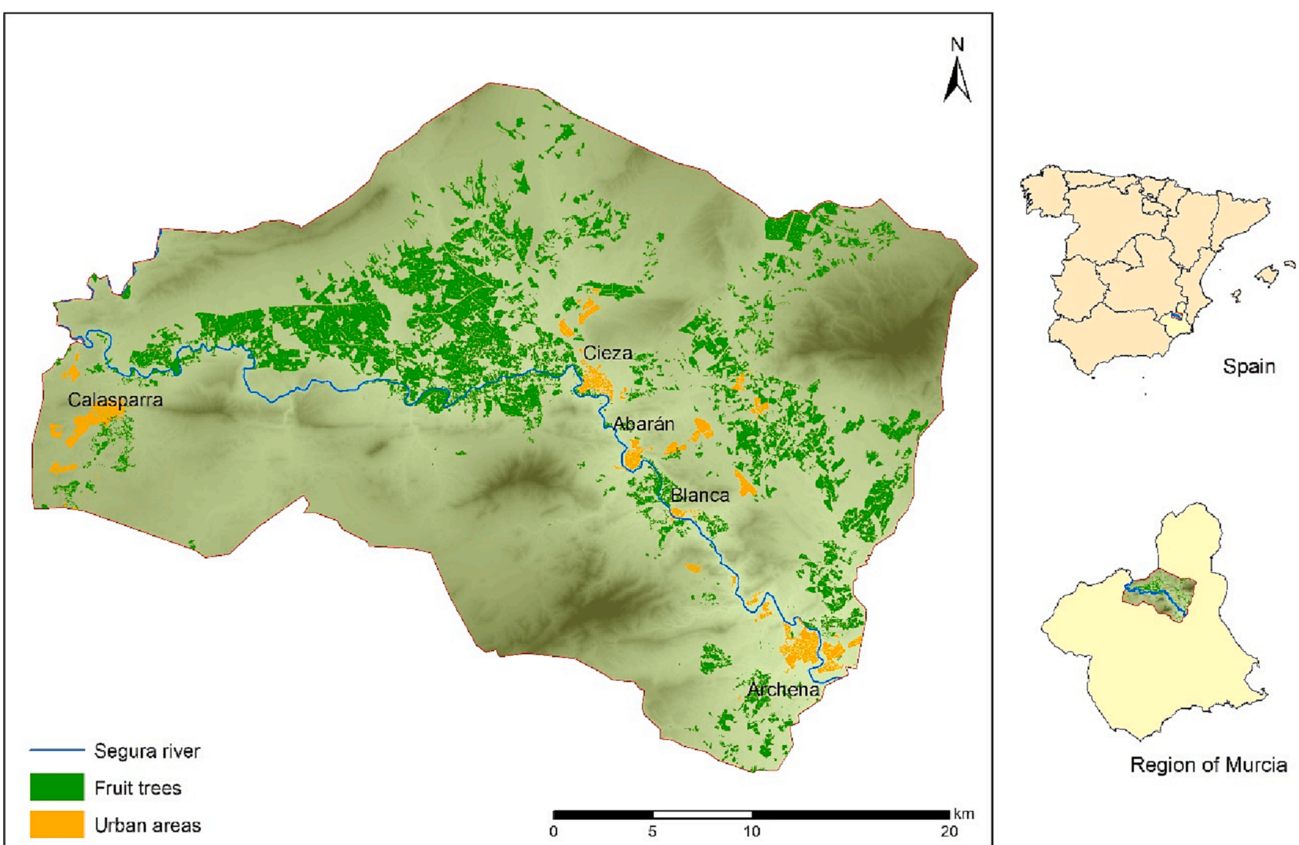

Fig. 1. The location of fruit trees and urban areas across the study region in southeast Spain.

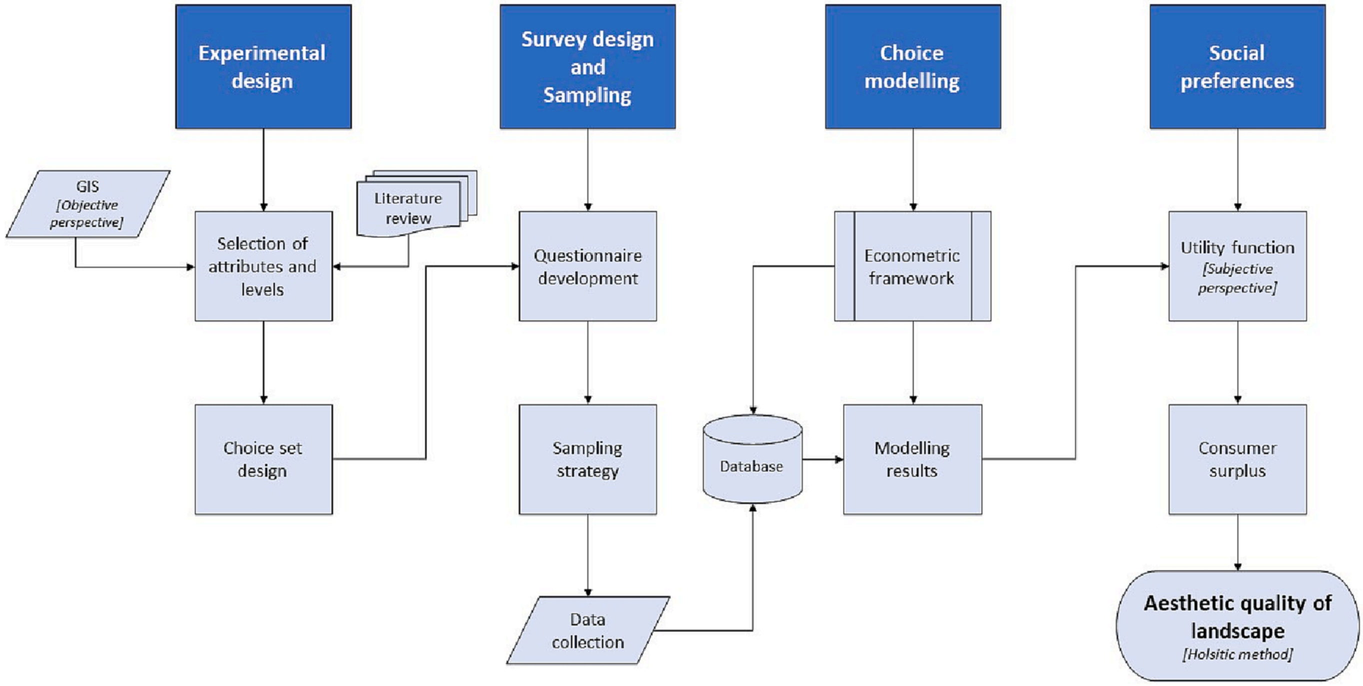

Fig. 2. Flowchart summary on the application of a holistic method for the aesthetic quality of landscape quantification.

assessment of the population's preferences for the landscape attributes, according to the objective levels of these attributes identified in the GIS.

2.2.1. GIS

GIS allows working with georeferenced information and separating spatial information into different and independent thematic layers, working on them quickly and efficiently, being a versatile and wide-ranging tool. The main potential of GIS is spatial analysis (overlapping, determination of influence zones, neighbourhood analysis, distances…), which gives these tools a great modelling capacity (Sastre, 2010). In this work, GIS, together with the literature review, have been a key tool for the selection of the different attributes and levels that can influence the aesthetic quality of the landscape.

The contemplation of the landscape is not limited to the boundaries of crop plots, and it is impossible to know whether the landscape observer is contemplating one or another crop plot. To avoid this problem, the unit of analysis was standardised in pixels of 25 × 25 m, being the resolution recommended in the literature to be able to identify the landscape elements at a detailed spatial level (Lu et al., 2008; Martínez-Harms & Balvanera, 2012). Thus, influence zones (buffers) of 150 m were created for each of the attributes considered with respect to these surfaces. This average distance was selected because it is one of the limiting distances at which the observation of more specific landscape elements such as ponds or natural vegetation becomes more imperceptible for this study area (Preston, 2001).

For the mapping of the aesthetic quality of landscape, population preferences for landscape attributes were added to the spatial information on these attributes identified in the GIS (MAPA, 2023; IGN, 2023). This mapping has been done at five aesthetic quality levels by natural breaks (very low, low, medium, high, and very high).

2.2.2. Choice experiment method

Choice experiments are a stated preference method based on multi-attribute and random utility theory (McFadden, 1974). In a choice experiment, individuals are asked to choose, among different alternatives, the one that provides them with the highest utility level. These alternatives are defined by a set of attributes (Barreiro-Hurle et al., 2018). From the utilities obtained it is possible, therefore, to calculate the utility function for any combination of attributes, or even to simulate social preferences for management policies if the attributes represent specific measures (Perni & Martínez-Paz, 2017). Thus, this work studies the contribution of landscape attributes in shaping its aesthetic quality in line with the specification used by van Zanten et al. (2016b). Therefore, the aim is not to carry out an economic valuation of landscapes or their components, but rather the perceived utility of each landscape attribute. In this way, there is methodological heterogeneity in assessing landscape preferences, with methods ranging from economic valuation to techniques based on landscape perception.

2.2.2.1. Determination and quantification of landscape attributes. The literature review of the characteristics and attributes of irrigated fruit tree landscapes, especially those referring to flowering phenomena (Junge et al., 2015), allowed the selection of six attributes for the specific case of irrigated fruit tree flowering landscapes in the Mediterranean area. Attribute selection was based on the physical characteristics that could be identified by GIS excluding landscape attributes such as number of colours, textures, or contrast (Arriaza et al., 2004). Those landscape attributes that had hardly any variability in the area, as is the case of the altitude of the plots or their slopes were also excluded in the final attribute's selection, since they did not have different representative levels (Martínez et al., 2016). Thus, the six attributes that were identify by GIS are (1) the proportion of the area covered of flowering fruit trees; (2) the presence of traditional hydraulic infrastructures, (3) intensive irrigation structures, (4) natural vegetation, (5) buildings and (6) asphalt roads. Table 1 shows the attributes and levels used in the study.

To validate this selection, a focus group was held with local experts made up of geographers, agronomists, economists, and environmentalists who confirmed the suitability of these attributes for the case study. This focus group also reached a consensus on the attribute levels to be used in the choice experiment. Thus, the first of the attributes considered, the proportion of the area covered of fruit trees, was divided into three levels: greater than90% fruit trees, <90% fruit trees and herbaceous, and < 90% fruit trees and bare soil. The two last levels of this attribute consider the proportion covered by fruit trees between 50 and 90 %, one of them with the rest of the area being covered by herbaceous

Table 1
Summary of attributes and levels used in a choice experiment assessing landscape aesthetic quality in the fruit trees in southeast Spain.

Attributes	Description	Levels	References
Proportion of area covered of fruit trees	Percentage of total area covered by fruit trees. (50% or more of fruit trees)	More than 90% fruit trees Lower than 90% fruit trees and herbaceous Lower than 90% fruit trees and bare soil	Arriaza et al. (2004); Martínez et al. (2016); Tagliafierro et al. (2016); Rodriguez-Entrena et al. (2017); Li et al. (2019)
Presence of traditional water features	Presence of traditional elements related to water, such as irrigation ditches or natural rivers.	Presence Absence	Arriaza et al. (2004); Grammatikopoulou et al. (2012); Martínez et al. (2016); Shr et al. (2019)
Presence of modernized water elements	Presence of modernized elements related to water, such as water ponds.	Presence Absence	Arriaza et al. (2004); Martínez et al. (2016); Wang et al. (2016); Benning et al. (2018)
Presence of natural vegetation	Presence of other natural vegetation such as pines, palm trees and riparian vegetation.	Presence Absence	Paracchini et al. (2014); Casado-Arzuaga et al. (2014); van Zanten et al. (2016a); Tagliafierro et al. (2016); Häfner et al. (2018)
Presence of buildings	Presence of new buildings associated with urban areas and farmhouses derived from intensive agriculture.	Presence Absence	Grammatikopoulou et al. (2012); Gulickx et al. (2013); Rechtman (2013); Martínez et al. (2016); Tagliafierro et al. (2016)
Presence of asphalt roads	Presence of asphalt roads crossing or surrounding fruit tree plots.	Presence Absence	Arriaza et al. (2004); Gulickx et al. (2013); Martínez et al. (2016); Martin et al. (2016)

and the other one by bare soil. The remaining five attributes were dichotomous, with two levels related to their presence or absence.

2.2.2.2. Choice experiment design. The selected attributes and levels were combined using a Bayesian D-efficient design, which seeks to minimize the standard errors of the estimated parameters in the derived choice model. In order to apply this design, the previous choice experiment results of the pilot survey of 18 respondents were used to obtain a first approximation of the parameters. This choice experiment had been designed, in turn, using an S-efficient design, seeking to minimize the sample size required for the survey (Rose et al., 2010). All designs were implemented using Ngene software.

Finally, 20 choice sets were generated, which were grouped into 4 blocks of 5 choice sets each, randomly distributed during the survey. Each choice set was composed of two generic alternatives representing different agricultural landscapes, as shown in Fig. 3.

Each respondent was asked to choose the landscape of flowering fruit trees that, according to their preferences and tastes, was most attractive to them out of the two alternatives available. To facilitate the choices, the survey was accompanied by an information leaflet showing real photographs presenting the combination of certain attribute levels. An example of these photographs is shown in Supplementary Fig. 1. In addition, respondents were presented with manipulated photographs of the landscape to show a comparison of the possible modifications that the landscape could undergo (Supplementary Fig. 2).

2.2.2.3. Utility model specification. According to random utility theory (McFadden, 1974), the utility U_{ij} for an individual i provided by an agricultural landscape alternative j can be decomposed into a deterministic (V_{ij}) and a stochastic (ε_{ij}) part, considered additively:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \sum_{k=1}^{K} \beta_{ik} X_{ikj} + \varepsilon_{ij} \tag{1}$$

where V_{ij} represents the observed elements of the utility determined by the k attribute levels (X_{ikj}), and ε_{ij} is a random error with an independent and identically distributed distribution of extreme values (Train, 2009). Assuming a linear relationship between attribute levels, β_{ik} is the individual marginal utility obtained from each attribute k, which reflects the change in the utility level in the presence of variations in the attributes of the agricultural landscape.

The multinomial logit model (Train, 2009) is widely used to estimate choice probabilities. However, this estimation considers a similar preference structure for all respondents, i.e., all respondents obtain the same utility for the landscape attributes/levels. To limit this restriction, preference heterogeneity can be analysed using latent class (LC) models. The assumption underlying LCs is that the population consists of groups of individuals (classes, s), with preferences being homogeneous among individuals within the same group (Colombo et al., 2009). Thus, LC models consider that individuals are heterogeneously distributed in the population, with a discrete distribution, in a finite number S of latent classes. Therefore, the probability that individual i belongs to class s can be written as:

$$Prob(clase = s) = \pi_s(\theta) = \frac{e^{\theta}}{\sum_{s=1}^{S} e^{\theta'}}, s = 1, \cdots, S; \theta_1 = 0 \tag{2}$$

where θ is the vector of related parameters to be estimated.

Therefore, the LC model was estimated as follows.

Attributes	Alternative A	Alternative B
Proportion of area covered of fruit trees	Fruit trees > 90 %	Fruit trees < 90 % and Herbaceous
Presence of traditional water features	✖	✔
Presence of modernized water features	✖	✔
Presence of natural vegetation	✔	✖
Presence of buildings	✖	✔
Presence of asphalt roads	✖	✔
Preferred alternative:	☐	☐

Fig. 3. Example of choice set for agricultural landscapes.

$$U_{ij|s} = V_{ij|s} + \varepsilon_{ij|s} = \sum_{k=1}^{K} \beta_{ik|s} X_{ikj} + \varepsilon_{ij|s}, s = 1, \cdots, S \quad (3)$$

where $\beta_{ik|s}$ is the marginal utility provided by the attribute for individual i in class s.

Attribute parameters are estimated simultaneously by maximizing the likelihood function (Train, 2009). The number of latent classes is selected by evaluating the fit of each model based on the likelihood value at convergence and the Akaike information criterion (AIC).

To estimate the impact of a given level of provision of landscape attributes on human well-being, it is necessary to calculate the consumer surplus (CS) associated with this level of provision, estimated according to Hanemann (1984) as:

$$CS_{im|s} = \left[ln\left(\sum e^{V_{im|s}} \right) - ln\left(\sum e^{V_{in|s}} \right) \right] \quad (4)$$

where $CS_{im|s}$ represents the consumer surplus derived from switching from a baseline situation n to a specific management scenario m in which at least a certain level of the landscape attributes has been modified because of, for example, the adoption of an agricultural management measure. Since no monetary attribute has been included in this work, CS will be measured in utilitarian terms. Therefore, $V_{in|s}$ is the utility obtained in the baseline situation for individual i in class s, while $V_{im|s}$ is the utility derived from applying a given management policy. Positive values of $CS_{im|s}$ represent individuals obtaining positive utility changes by applying a given agricultural measure, while negative values will indicate disutility.

2.3. Survey and data collection

Data collection was carried out by means of a structured questionnaire with three sections and 20 questions (See Supplementary file). The first section included questions on the general assessment of the landscape. The second section presented the choice experiment question. The last section included questions related to sociodemographic, spatial characteristics and environmental attitudes of the respondents. Spatial characteristics were considered by estimating the Euclidean distance from where respondents resided (given their zip code) to the nearest fruit trees plots in the study area (Martínez-Paz et al., 2021). Environmental attitudes were measured by affective, verbal, and real ecological commitment indices, using a five-point Likert scale to evaluate a set of statements in the questionnaire (Zabala et al., 2022).

The pilot survey of 18 individuals was conducted in early March 2021 to improve the understanding of the initial questionnaire and clarify the valuation scenario. The final survey was carried out in person during the months of March and April 2021, which coincided with the end of the flowering period. A randomly selected sample from the 532,820 households in the Region of Murcia was used. The survey was carried out in public places, usually frequented by all the inhabitants of the Region of Murcia (parks, government offices, universities, etc.). For the sampling, the representative population proportions by region were maintained. Finally, a representative sample of 493 surveys was obtained, which, for a binary variable and a confidence level of 95%, gives a sampling error of<5% in intermediate proportions.

Table 2 shows the population survey description, which identifies the profile of the average respondent as a man, 41 years old, with university studies (completed or in progress) and an active worker. The most frequent is a 4-member household (3.1 on average), with an average family income of 2,157 €/month. These characteristics do not differ significantly from the census values for the Region of Murcia (CREM, 2022), which confirms the representativeness of the sample and its validity for analysis and inference on the population. Overall, 26.37 % of respondents are users of the fruit trees areas during the flowering period, since in the last three years they have carried out some kind of activity in the area. Contemplating the landscape (20.89 %), hiking (13.59 %) and photography (9.13 %) were the most frequent activities.

Table 2
Sample description.

Description	Mean	SD
Household size (n° members)	3.13	1.24
Age (years)	41.39	14.93
Monthly income (€/household/month)	2,157	1,208
Active worker (% yes)	70.79	
Educational level (%):		
Low level	6.29	
Secondary	34.28	
High level	46.04	
Gender (% women)	48.68	
Users (%)	26.37	
Activities (% people performing activities):		
Contemplate the landscape	20.89	
Hiking	13.59	
Photography	9.13	
Gastronomy	7.91	
Transit zone	7.30	

Supplementary Table 1 shows the location characteristics of the respondents such as the distances of each respondent from the nearest fruit trees in the Cieza area and whether respondents can observe different types of agricultural landscapes from their residence. Respondents are, on average, 23.86 km from the study area, while 49.29 % can observe some type of agricultural landscape from their residence. Fruit tree landscapes are the most frequent (20.28 %), followed by rainfed (11.56 %) and intensive irrigated landscape (6.69 %).

3. Results

3.1. Characteristics of the aesthetic quality of the landscape

The characteristics of each of the attributes used in the aesthetic quality of landscape assessment of the agroecosystem of irrigated fruit trees in bloom are shown in Table 3, which shows the percentage of area or presence of each attribute for the study area. These data were obtained by performing a spatial analysis of the study area using GIS. To determine the presence of traditional elements, vegetation, etc., the spatial unit of analysis was standardized using pixels of 25 × 25 m, the resolution recommended in the specialized literature for this type of analysis (Lu et al., 2008; Martínez-Harms & Balvanera, 2012). On the structured surface, polygons of influence zone (buffers) of the attributes were created considering a maximum Euclidean distance of 150 m from which an element can be contemplated (Preston, 2001). This process eliminates the error that would be made if the unit of analysis were the presence of elements in each plot, given the very different sizes of the plots (from 0.016 to 50 ha).

Taking into account the percentage of fruit tree cover in each pixel, it can be observed that from the 11,915 ha of fruit trees considered, in 71.32 % of the area there is a fruit tree cover of more than 90 %, while in 15.25 % of the area there is a fruit tree diversification with herbaceous crops. In the remaining 13.43 % of the area, fruit trees appear in the landscape next to uncultivated (fallow) land. As for the presence of the remaining attributes in the landscape, in 9.21 % and 22.20 % it is

Table 3
Description of aesthetic quality landscape attributes.

Description	% Area
Proportion area covered of fruit trees	
> 90% fruit trees	71.32
< 90% fruit trees and herbaceous	15.25
< 90% fruit trees and bare soil	13.43
Presence of traditional water features	9.21
Presence of modernized water features	22.20
Presence of natural vegetation	12.85
Presence of buildings	10.20
Presence of asphalt roads	23.13

possible to observe surfaces with traditional and modernized water features, respectively. Approximately 13% of the areas show natural vegetation other than crops, while in 10.20% and 23.13% of the area it is possible to observe the more artificial elements that make up the landscape, such as buildings and asphalt roads.

3.2. Social preference modelling

Population preferences are analysed using an LC model given the improved fits of this model with respect to the multinomial logit model (Supplementary Table 2) (LRtest = 86.642; $\chi^2_{0.05}$ = 23.685) and by allowing analysis of the social preference heterogeneity. The LC model (Table 4) collects the utility functions of the identified population groups based on their preferences for the aesthetic quality of landscape attributes. For this purpose, the optimal number of classes is first determined, for which modelling from 1 to 4 classes is evaluated. The 3-class model presents better values of the evaluation statistics (adjusted coefficient of determination and the AIC criterion), retaining the same for the analysis. In this model, class 1 contains almost three quarters of the respondents (74%), class 2 contains 12% and class 3 contains the remaining 14%.

In class 1, respondents' choices are mainly determined by the presence of traditional hydraulic infrastructures, areas with more than 90% fruit trees and the presence of natural vegetation. On the other hand, for these respondents, the area under fruit trees and herbaceous, modernized water features and roads has a negative effect on the aesthetic quality of the landscape. Thus, this class comprises people who positively value the fruit tree landscape in its most natural state.

In class 2, respondents show an exclusive preference for the presence of buildings, while the rest of the attributes have a negative effect on the aesthetic quality of the landscape. Likewise, the presence of modernized water features is non-significant for this class. This class comprises people who do not value the landscape of irrigated fruit trees in bloom and have a greater preference for the urban landscape.

Class 3 members have a similar general preference pattern as class 1 respondents, but the combination of fruit and herbaceous areas increases their aesthetic quality of the landscape, even more than fruit trees alone. The presence of all other attributes, except buildings, is also considered positive in landscape quality, so it should be noted that this class includes those with a preference for diverse fruit trees landscape.

The socio-demographic descriptions for each class are presented in Supplementary Table 3 and show statistically significant differences. Thus, the members of class 1 are mostly female and are those who can barely observe agricultural landscapes from their residence. Class 2 is mainly male, with larger families, resides at a greater distance from the study area, agricultural landscapes are visible for them from their residence, and has the lowest income and education level. In class 3, respondents with the highest income and education level are concentrated, also living closest to the study area. In terms of the activities carried out by the respondents in the fruit agroecosystems during the flowering period, significant differences were only observed in the frequency of hiking, this being the main reason for visiting the study area for respondents in class 3. The ecological commitment indices, age, being an active worker, being a user of the area, or the observation of the different types of landscape, despite showing differences between classes, are not significant.

Table 4
Latent class estimation results showing the utility of landscape attributes.

Variables	LC-Class 1 Coefficients	LC-Class 2 Coefficients	LC-Class 3 Coefficients
> 90% fruit trees	0.136 (0.085) **	−7.641 (4.248) **	2.492 (1.003) ***
< 90% fruit trees and herbaceous	−0.137 (0.094) *	−9.101 (5.516) *	4.405 (1.625) ***
Presence of traditional water features	0.343 (0.061) ***	−2.013 (1.188) **	1.360 (0.726) **
Presence of modernized water features	−0.068 (0.057) *	−0.439 (0.595)	−1.216 (0.457) ***
Presence of natural vegetation	0.083 (0.061) *	−2.429 (1.645) **	2.344 (0.795) ***
Presence of buildings	0.027 (0.064)	8.633 (5.001) **	−0.597 (0.445) *
Presence of asphalt roads	−0.155 (0.060) ***	−3.011 (1.270) ***	0.792 (0.584) *
Class Assignment Probability	0.74	0.12	0.14
Constant	1.667 (0.260) ***	−0.195 (0.302)	
Model description			
N. observations	2,465		
N. respondents	493		
Maximum Likelihood	−1,625.752		
Adjusted R^2	0.035		
AIC	3,297.50		

Statistically significant at a level of *0.1, **0.05 or ***0.01. The level "< 90% fruit trees and bare soil" was the reference category for the proportion area covered of fruit trees attribute with 3 levels.

3.3. Application of management measures and mapping of the aesthetic quality of the landscape

Based on the estimated preferences, it is possible to assess the effect that the application of different agricultural management measures or policies will have on the provision of the aesthetic quality of the landscape. For this purpose, the aesthetic quality of the landscape is assessed in terms of utility, using as an indicator the variation in consumer surplus (CS), which measures the gain or loss of well-being due to changes in the attribute levels due to each agricultural management measure with respect to the baseline situation.

Thus, the baseline situation (SC0), defined according to the values presented in Table 2, will be compared with three possible management scenarios, characterized in Table 5. The first scenario (SC1) is based on the intensification of the fruit tree crops, which would result in the presence of modern irrigation ponds and buildings associated with this agriculture, and roads favouring accessibility. The second scenario (SC2) is related to a more natural agricultural landscape. Therefore, the presence of natural vegetation and traditional water features is encouraged, establishing a landscape without modernized features. The third scenario (SC3) refers to a diverse agricultural landscape, with the presence of all attributes and fruit trees along with other herbaceous crops.

For these analyses, in addition to the 3 latent classes, we have considered what we have called the aggregate class, which is constructed by considering the parameters of each class and their

Table 5
Agricultural management policy scenarios definition.

Variables	SC1 Intensive agricultural landscape	SC2 Natural agricultural landscape	SC3 Diverse agricultural landscape
Proportion area covered of fruit trees	> 90% fruit trees	> 90% fruit trees	< 90% fruit trees and herbaceous
Presence of traditional water features	Absence	Presence	Presence
Presence of modernized water features	Presence	Absence	Presence
Presence of natural vegetation	Absence	Presence	Presence
Presence of buildings	Presence	Absence	Presence
Presence of asphalt roads	Presence	Absence	Presence

proportion (probability class assignment) in the total sample (Table 4).

Supplementary Table 4 shows, for the three classes and the aggregate class, the average value of current aesthetic quality of the landscape (SC0) and that of the three management scenarios. Table 6 shows the normalized aesthetic quality of the landscape where the minimum and maximum of the scenarios for each class have been considered, resulting in a normalized aesthetic quality of the landscape index with range 0 and 1. Table 6 also includes the CS with respect to SC0, that is, the difference between the aesthetic quality of the landscape average values of each scenario and the initial aesthetic values (SC0) of the fruit trees.

Considering the current situation in the study area (SC0), the aggregate class shows the lowest aesthetic quality of landscapes in mean (0.371). As for the three classes, class 1 has an intermediate value (0.456), which is higher in class 3 (0.622) and lower in class 2 (0.384).

The application of any of the three proposed management scenarios would generate an increase in the mean aesthetic quality of the landscape for the aggregate class, with the diversified scenario (SC3) showing the highest aesthetic values (0.725), followed by the intensive (SC1) (0.653) and the natural (SC2) (0.629) scenarios. When analysed by classes, a greater variability is observed, where the most intensive scenario of the agricultural landscape (SC1) would increase the aesthetic quality for class 2, but not for the other two classes. If the most natural scenario (SC2) were applied, the highest aesthetic quality of the landscape would be obtained for class 1, and class 2 would have the lowest aesthetic quality. For the diversified scenario (SC3), class 3 obtains the highest aesthetic quality of the landscape. A relationship between the CS and the aesthetic quality of the landscape of each scenario is observed, so that, under SC2 (natural), class 1 obtains the highest gains in CS, under SC1 (intensive) class 2 has the highest gains in CS, while under SC3 (diverse) it is the aggregate class and class 3 that show the highest increases in CS.

To assess the aesthetic quality of the landscape according to these scenarios, the aesthetic quality of the landscape index is divided into five intervals of equal size (Table 7). This makes it possible to assess the aesthetic quality of the landscape distribution in terms of surface area for both the baseline situation and the one resulting from the different scenarios proposed.

Of the 11,915 ha of irrigated fruit trees, the low aesthetic quality of the landscape that the current situation has for the general population can be highlighted. If a management policy based on agricultural landscape intensification (SC1) were applied, there would be an increase of 75% of the surface with medium and high aesthetic quality levels, surfaces that would increase to 77% if a policy based on the landscape naturalization (SC2) were applied. If measures for landscape diversification (SC3) were applied, there would be a 90% increase in areas with high and very high aesthetic quality levels.

Table 6
Standardized average values of aesthetic quality of landscape for the Latent classes and CS values.

Scenarios	Mean	SD	Min	Max	CS
Aggregate Class					
SC0 – Baseline	0.371	0.154	0.096	1	–
SC1 – Intensive	0.653	0.154	0.025	0.928	0.282
SC2 – Natural	0.629	0.154	0	0.904	0.258
SC3 – Diverse	0.725	0.154	0.096	1	0.354
Class 1					
SC0 – Baseline	0.456	0.089	0.184	0.771	–
SC1 – Intensive	0.315	0.089	0	0.587	−0.141
SC2 – Natural	0.728	0.089	0.413	1	0.272
SC3 – Diverse	0.412	0.089	0.097	0.684	−0.044
Class 2					
SC0 – Baseline	0.384	0.116	0.118	0.833	–
SC1 – Intensive	0.734	0.116	0.285	1	0.350
SC2 – Natural	0.448	0.116	0	0.715	0.064
SC3 – Diverse	0.566	0.116	0.118	0.833	0.182
Class 3					
SC0 – Baseline	0.622	0.109	0.344	1	–
SC1 – Intensive	0.378	0.109	0	0.656	−0.244
SC2 – Natural	0.667	0.109	0.289	0.945	0.045
SC3 – Diverse	0.722	0.109	0.344	1	0.100

Table 7
Surface area distribution (%) of the aesthetic quality of the landscape for population classes according to management scenarios.

Scenarios	Very low (0–0.2)	Low (0.2–0.4)	Medium (0.4–0.6)	High (0.6–0.8)	Very high (0.8–1)
Aggregate Class					
SC0 – Baseline	3.97	74.54	12.91	6.98	1.60
SC1 – Intensive	1.37	6.67	57.32	21.04	13.60
SC2 – Natural	1.60	6.98	12.91	74.54	3.97
SC3 – Diverse	0.16	5.29	10.62	55.50	28.43
Class 1					
SC0 – Baseline	0.38	18.46	77.63	3.53	0
SC1 – Intensive	5.73	76.53	17.74	0	0
SC2 – Natural	0	0	5.47	75.70	18.83
SC3 – Diverse	2.70	49.17	46.22	1.91	0
Class 2					
SC0 – Baseline	2.22	77.39	14.85	4.53	1.01
SC1 – Intensive	0	1.61	14.00	60.31	24.08
SC2 – Natural	2.03	17.92	75.09	4.96	0
SC3 – Diverse	1.08	12.00	56.29	29.59	1.03
Class 3					
SC0 – Baseline	0	2.49	37.53	53.65	6.33
SC1 – Intensive	6.33	65.71	25.47	2.49	0
SC2 – Natural	0	2.75	16.96	71.51	8.78
SC3 – Diverse	0	2.04	9.69	66.50	21.77

The population results are graphically supported by the spatial representation of each of the management scenarios (Fig. 4). Thus, it is possible to verify how the aesthetic quality of the landscape is distributed spatially, by observing the high and very high aesthetic quality levels when applying the diversified scenario, and of medium and high levels when applying the intensive and naturalized scenarios. These results can be further explored by taking into account the heterogeneity for the three identified population classes (Supplementary Figs. 3–5).

Thus, agricultural landscape intensification (SC1) would result in an increase of more than 90% of the study area that had high and very high aesthetic quality levels for class 2. This would however lead to a reduction of the aesthetic quality in the other two classes, with an increase of almost 80 % of low and very low aesthetic quality levels for class 1 and of almost 95 % for class 3.

A policy based on landscape naturalization (SC2) would increase the area of fruit trees with high and very high aesthetic quality levels by more than 95% for class 1 and more than 25% for class 3. On the other hand, there would be an absence of these aesthetic quality levels for class 2. This class would consider more than 80% of the area as medium quality and 18% as low quality.

Finally, landscape diversification (SC3) would produce an increase in high and very high aesthetic quality levels for classes 2 and 3 up to 80% and 30% respectively. On the contrary, this trend would lead to a reduction of aesthetic values for class 1, with an increase of 65% of area with low and very low aesthetic quality levels.

4. Discussion

The social interest in the aesthetic values of the agricultural landscape has been demonstrated, with a heterogeneous distribution among the population. These findings have been previously justified in the literature due to changes in agricultural land use associated with technological progress and demographic pressure (Pecher et al., 2018), awareness of environmental and landscape degradation (Assandri et al., 2018), and the widespread of the leisure society (Hahn et al., 2018). Here we have proposed and applied a holistic method for quantifying the aesthetic qualities of landscape that integrates GIS tools and a choice experiment for this purpose. Using the Mediterranean agroecosystem of irrigated fruit trees in bloom as a case study, the effect of different

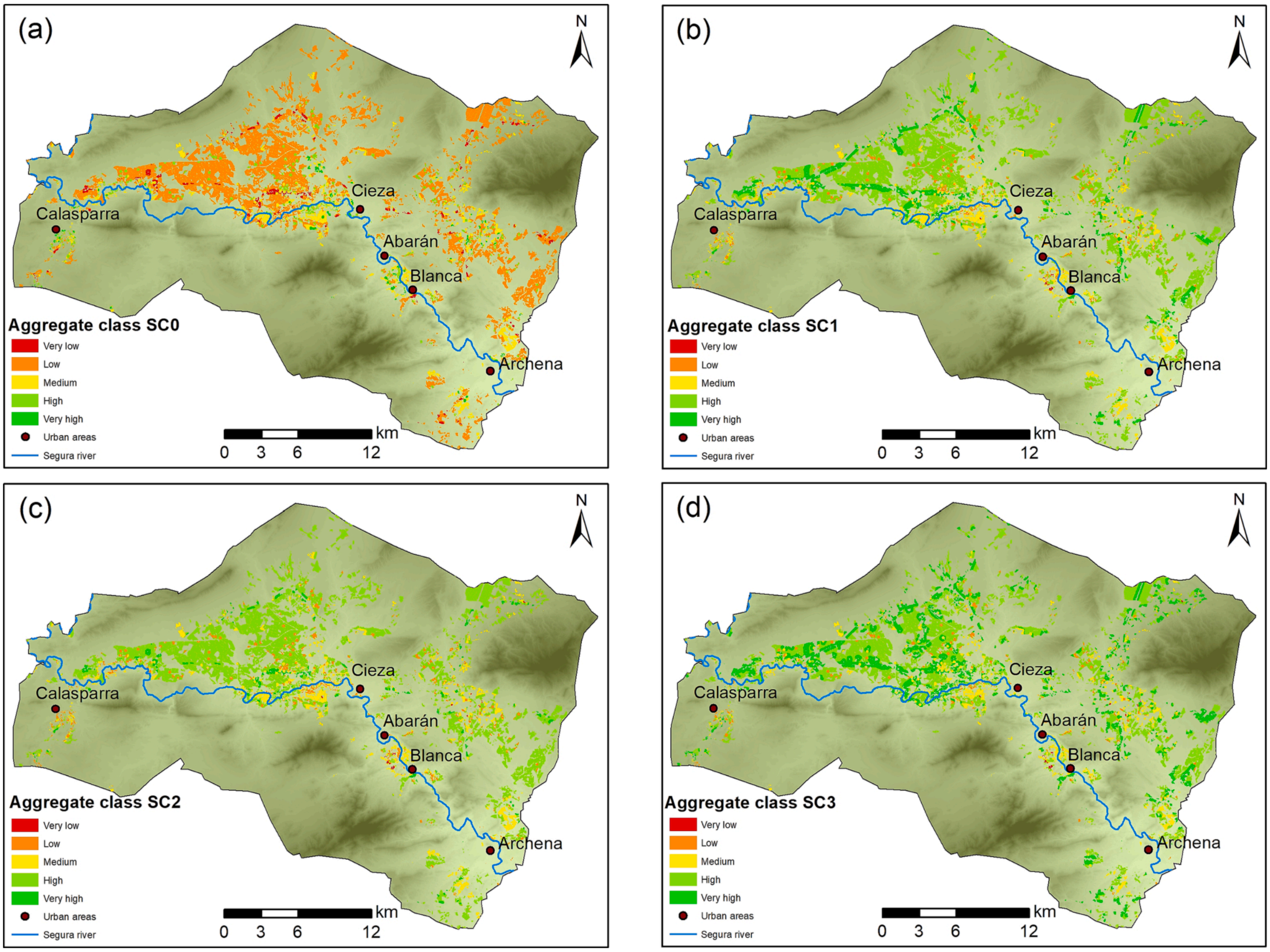

Fig. 4. Spatial distribution of the aesthetic quality of the landscape for aggregate class according to scenarios: SC0 (a), SC1 (b), SC2 (c), SC3 (d).

management policies on landscape aesthetic quality has been quantified. In addition, heterogeneity in social preferences has led to different results regarding the spatial distribution of this cultural ecosystem service.

We identified three different groups with well-defined preferences for aesthetic quality of the landscape. Two of the population groups (class 1 and 3) have positive preferences for the characteristic elements of fruit trees landscapes, while the remaining group (class 2) show almost exclusive preferences for the presence of buildings. Considering the most representative group, class 1 collects almost 75% of the population, which was formed by individuals with a clear preference for a homogeneous fruit trees landscape with the presence of traditional water features and natural vegetation. Thus, for them the most naturalized elements of irrigated agroecosystems will play a key role in the aesthetic values provision (Martínez et al., 2016).

In order of preference, the whole population prefers a diversified landscape scenario, followed by intensive and naturalized landscape management policy. Thus, a preference of the population for a diversified landscape with natural and anthropic elements has been demonstrated, in line with the work of Massoni et al. (2016) demonstrating tourists' preferences for a combination of agricultural and natural elements in rural landscapes and Kirillova et al. (2014) highlighting the positive perception of tourists for landscape diversity. These results can be a reference for land managers of other similar Mediterranean agricultural landscapes, such as those of the Huerta of Valencia (Spain), areas of Arab Maghreb countries (Morocco, Algeria and Tunisia), or Veneto Plain (Italy) (Tempesta, 2010; Benabdelkader et al., 2021) when implementing agricultural policies that promote the conservation of natural and diversified landscape elements. Thus, the case study goes beyond its regional interest, constituting a starting point to learn about the impact of the aesthetic quality of the landscape on the well-being achieved by other agricultural ecosystems (Albaladejo-García et al., 2023). From now, we can study the management policy effects in each population class. The management policy based on landscape naturalization increases the well-being of the population in class 1. Doing so leads to an increase in high and very high aesthetic quality levels through the agricultural ecosystems (Alcon et al., 2020), in wetlands (Perni & Martínez-Paz, 2017) or in other semi-arid areas (García-Llorente et al., 2012). As with the whole population but with a higher intensity, class 3 prefers complex and heterogeneous landscapes, where different types of landscape elements are combined. The presence of buildings does not influence the aesthetic quality of the landscape for classes 1 and 3, in line with other studies showing that urbanized areas do not contribute to landscape quality with respect to more open or natural areas (Sahraoui et al., 2016). Thus, implementing a policy based on the agricultural intensification could worsen the aesthetic quality (except for class 2, the least representative respondent class), in line with the results of Zabala et al. (2021) on the lower well-being caused by intensive agriculture.

Thus, according to most of the population's preferences, policies should be implemented to promote the establishment of fruit trees in the Cieza area, together with actions that encourage cultivation practices in favour of more naturalized agroecosystems, as well as incentives for the conservation of traditional irrigation features. However, although this type of initiative would be supported by most of the population (classes 1 and 3), around 12% of the population (class 2) would be less supportive since they show a greater preference for the presence of elements associated with buildings and urbanisation.

Assessing preference heterogeneity can improve decision-making by identifying different target groups with different interests towards the landscape. It can also contribute to an appropriate allocation of available resources to design management measures in a heterogeneous society. Thus, despite the interest of the social majority (classes 1 and 3) in promoting more naturalised cultivation practices, it is expected that around 12% of the population (class 2) is reticent to promote them, as they show a greater preference for the presence of elements associated with buildings and urban constructions. Thus, the promotion of a landscape that enhances the tastes and preferences of the majority social classes can be developed without undermining the well-being of the rest of society when fair exchange relations are established between the two social groups. For example, one of the feasible compensation systems would involve the compensation of profits between classes 1 and 3 with respect to class 2, the latter receiving compensation for the disutility that such a policy would have caused them. The feasibility of this system depends on its simplicity and operability, for which the analysis of the socio-demographic differences between classes is particularly relevant. In this way, and given that the members of class 2 have a lower income than the rest of the classes, the disutility generated for this class by the increase in the surface area of fruit trees and the naturalisation of agriculture can be compensated by means of income transfers between the rest of the classes and in favour of class 2 (Jack et al., 2008).

From the mapping of the aesthetic quality of the landscape, the spatial provision of this cultural ecosystem service has been highlighted. It has been shown its distribution and levels of provision in a graphical form, which expands the possibility of making the findings more accessible to the general public (Martínez et al., 2016). This spatial representation can allow land managers to be informed about the potential location of recreational and tourism activities, by identifying the areas with the highest aesthetic qualities for the population, favouring tourism planning that is as efficient as possible and accepted by most of the population. In this way, these results will make it possible to know in which areas farms should not be abandoned or crops changed and provides the background for a further study on where to create viewpoints to observe the landscape or to condition recreational areas (Guardiola, 2018).

The quantification and location of areas with high aesthetic quality values in the current situation and under different management policies also allows us to know, at a detailed spatial scale, the synergies, and trade-offs of the aesthetic quality of the landscape with respect to other ecosystem services such as food supply or biodiversity (Plieninger et al., 2013). Thus, the aesthetic quality of the landscape is mostly promoted by increasing the proportion area covered of fruit trees, the presence of traditional irrigation features, as well as a greater provision of natural vegetation, thus enhancing the generation of trade-offs and win–win solutions between provisioning, regulating and cultural ecosystem services. The linkage of the aesthetic quality of the landscape with a greater presence of fruit trees could translate into improved food provisioning (Zabala et al., 2021), while the naturalization of agricultural landscapes through natural vegetation may link to increases in biodiversity in agroecosystems (Rosa-Schleich et al., 2019). However, there may also be trade-offs between the aesthetic quality of the landscape and increased pressure on water resources in the territory, which may result in reduced ecosystem service provision associated with water resources within the study area and have implications for a wide range of ecosystem services in areas downstream from the study system.

As future directions, GIS attribute characterisation could also be complemented with fieldwork that would allow greater accuracy in locating the differential and influential elements, such as, waterwheels or other types of singular constructions. In addition, this type of holistic assessment could be extended to other crops representative of the Mediterranean area (e.g., citrus, vegetables…) and at different times of the year. Future research could also address other aspects that influence the aesthetic quality of the landscape perception, such as the soundscape (Chen et al., 2021), which is particularly relevant in tourist agricultural areas where there is a high frequency of vehicles, people, and wildlife transit.

5. Conclusions

The aesthetic quality of the landscape of irrigated fruit trees in the Mediterranean area was assessed using a method that combines an objective approach (spatial quantification of attributes) and a subjective approach (social preferences for the attributes). This has allowed, in addition to spatially quantifying the aesthetic quality levels, to study the population's preference heterogeneity for the attributes that underpin this cultural ecosystem service. A diversified landscape with a high presence of flowering fruit trees in combination with elements of traditional irrigation and natural vegetation was preferred by the population.

We can conclude that decision makers can optimize the aesthetic quality of the landscape provision in agroecosystems by conserving heterogeneous landscapes. However, heterogeneity can be considered in such a way that places that meet the preferences of other population groups are also preserved, such as the presence of the most traditional and natural landscape elements, limiting such elements as irrigation reservoirs and enhancing hotspots of natural vegetation. These considerations should help managers, given their link to the tourism and hospitality industry, which are vital to the economy of rural areas generating activities and being a brake on rural depopulation. Likewise, the information obtained from the aesthetic quality values assessment and mapping can serve as an additional criterion for land use planning, by limiting the activities that have a negative impact on the landscape in those areas with the highest aesthetic quality.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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