Landscape assessment via regression analysis

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Abstract

This paper presents a methodology for assessing the visual quality of agricultural landscapes through direct and indirect techniques of landscape valuation. The first technique enables us to rank agricultural landscapes on the basis of a survey of public preferences. The latter weighs the contribution of the elements and attributes contained in the picture to its overall scenic beauty via regression analysis. The photos used in the survey included man-made elements, positive and negative, agricultural fields, mainly of cereals and olive trees, and a natural park. The results show that perceived visual quality increases, in decreasing order of importance, with the degree of wilderness of the landscape, the presence of well-preserved man-made elements, the percentage of plant cover, the amount of water, the presence of mountains and the colour contrast.

Keywords: landscape assessment, visual quality, landscape elements, landscape value.
JEL Classification: H41, Q21, Q26.

1. Introduction: landscape evaluation techniques

As Briggs and France (1980) point out, there are two main approaches to the evaluation of landscape:

- *Direct methods* compare the scenic preferences of members of the public for landscapes in order to reach a consensus (Arthur *et al*., 1977; Briggs and France, 1980; Pérez, 2002).
- *Indirect methods* evaluate the landscape on the basis of the presence and/or intensity of designated features (Fines, 1968). Such methods aggregate landscape components in order to obtain a total value, implying that overall scenic quality is the sum of its parts (Linton, 1968; Tandy, 1971, Land Use Consultant, 1971).

Shafer *et al*. (1969) presented a compromise between descriptive methods and preference models, namely, holistic models such as psychophysical and surrogate component models (Buhyoff and Riesenman, 1979). This approach has found favour in recent years and is supported by the use of statistical techniques to determine the mathematical relationships that exist between landscape components and the scenic preferences of observers (Palmer, 1983; Daniel and Vining, 1983; Buhyoff *et al*., 1994; Wherrett, 2000; Real *et al*., 2000; Daniel, 2001). This is the approach selected in the present paper.

As in several earlier works that have attempted to assess the scenic preferences of observers, we used photographs of the rural landscapes (Dunn, 1976; Law and Zube, 1983; Shafer and Brush, 1977; Shuttleworth, 1980b; Wherrett, 2000; Pérez, 2002). This approach is based on the assumption that aesthetic judgements of panels provide an appropriate measure of landscape quality (Daniel and Vining, 1983).

The following sections of this paper consist of three main parts. The first explains the methodology followed in this research. The second presents the results of the survey on landscape public preferences and the mathematical model. Finally, some conclusions are outlined.

2. Methodology

The methodology followed in this paper can be divided into five distinct parts. First, using geographic information systems, the area of study was classified into relatively homogeneous landscape units. Second, we took photos that were intended to cover the most important land uses within each unit. Third, we assessed the scenic beauty of the landscape via a survey of observer preferences. Fourth, after measuring the visual quality assigned to each scene on a derived interval scale, we evaluated the intensity of the landscape attributes and elements present in each image using categorical or nominal variables. Finally, we regressed the explaining variables against overall picture value in order to obtain the contribution of each component to perceptions of visual quality of the landscape.

Splitting the area into homogeneous units

Using Geographical Information System techniques the area of study, the northern part of the Province of Cordoba in Andalusia, Spain, was divided into homogeneous units from a visual point of view. The variables used for the classification were land use, altitude and slope (gradient). From the CORINE land cover 1/50,000 (European Environment Agency, 1995), four types of land use were identified: buildings and infrastructures, wet areas, agricultural fields and forestry.

Photography

More than 400 photos were taken in the study area between February and April 2001, with the aim of capturing the most relevant features of the rural landscape of each unit. The photos were taken using an HP 1000 digital camera on clear days. For example, if the most important crop in a particular unit was olive trees, we looked for olive tree fields on flat or mountainous areas, with or without herbaceous cover, with or without man-made elements, either positive (typical Andalusian white houses, farm-buildings and beauty spots) or negative (power lines, industries and roads), with or without other herbaceous crops, etc. The result is a wide variety of pictures of olive trees fields with most of the elements that were to be included in the visual quality regression analysis.

Panels

A selection of photos was made for presentation to observers on ten panels, with sixteen scenes on each panel. The 160 scenes were assigned strictly randomly to the ten panels.

Survey of observers' preferences

Following a convenience sampling design (Malhotra and Birks, 2000), the sample of 226 subjects consisted of agricultural students (58 per cent), participants in a landscape valuation course (22 per cent), art students (11 per cent) and farmers from the study area (9 per cent). Each subject ranked an average of 7.33 panels, so that the total number of scores for each of the 160 photos was $226 \cdot (7.33/10) = 166$.

Observers were asked to choose the four photos they liked best and the four they liked least. The "best" was given a score of +4 points, the second best +3 points, and so on. The "worst" was scored –4 points, the second worst –3 and so on. The eight pictures not chosen were each allocated 0 points. Then we obtained an average visual quality index (AVQ index) for each scene, which was the dependent variable in the visual quality regression model.

Assessing the intensity of the landscape attributes and elements

In order to measure the intensity of the landscape attributes and elements present in the picture, a group of six researchers from our Research Institute and the University of Cordoba scored each of the 160 photos according to the scale of measurement shown in Table 1.

Table 1. Scale of measurement of landscape attributes and elements

Variable	**Scoring**
Water movement	No movement= 0; Movement= 1
Amount of water	No water= 0; River= 1; Lake= 2; Dam= 3
Percentage of land covered by vegetation	0-25%= 0; 25-50%= 1; 50-75%= 2; 75-100%= 3
Type of vegetation	No vegetation= 0; Herbaceous and bushes= 1; Mix vegetation (bushes+trees)= 2; Trees= 3
Horizon	Almost flat= 0; Slighly wavy= 1; Some mountains= 2; Mountains dominate the scene= 3
Presence of positive man-made elements (sights and typical houses)	None= 0; One element= 1; Two elements= 2; Three or more elements= 3
Presence of negative man-made elements (roads, industries, power lines, etc.)	None= 0; One element= 1; Two elements= 2 Three or more elements= 3
Number of colours	One colour= 1; Two colours= 2; Three or more colours= 3
Internal contrast	Weak colour contrast= 0; Clear colour contrast= 1
Presence of alignments	None= 0; Presence of alignments= 1
Scale effect	No element presents scale effect= 0; Presence of scale effect= 1
Focal view	No focal view = 0; Focal view = 1
Texture	Smooth= 1; Medium = 2; Rough = 3
Degree of wilderness	Houses+roads+ other= 0; Few isolated elements= 1; Crops without man-made elements= 2; Wild vegetation= 3

3. Results

The coefficients of the linear regression model are shown in Table 2. The regression analysis suggests the importance of the degree of wilderness to explain the visual quality of landscape. It is also interesting to note how positively evaluated man-made elements improve the perceived quality of rural scenery.

Table 2. Regression analysis of the scoring on explanatory variables

Variables	**Beta**		**Significance**	
	Unstand.	**Stand.**	***t***	**Sig.**
(Constant)	-2.857		-7.989	0.000
Amount of water	0.445	0.175	2.969	0.003
Degree of wilderness	0.831	0.409	5.841	0.000
Horizon	0.319	0.172	3.013	0.003
Positive man-made elements	0.721	0.342	5.500	0.000
Negative man-made elements	-0.302	-0.134	-2.078	0.039
Percentage of vegetation	0.370	0.215	3.762	0.000
Colour contrast	0.496	0.165	2.764	0.006

n=160; R2= 0.52; R2adj.=0.50; F=24.03 (Sig.=0.000)

In order to accept the above model we tested the normality of the residuals, multicollinearity and heterocedasticity.

Normality of the residuals. Due to the sample size (n=160), the usual test procedures (the *t* and *F* tests) are still valid asymptotically (Greene, 1997, p. 341; Gujarati, 1995, p. 317), even though the residuals do not follow a normal distribution (Kolmogorov-Smirnov = 0.08, p= 0.02).

Multicollinearity. According to Menard (1995), a tolerance value lower than 0.20 suggests a multicollinearity problem. The minimum value in our model was 0.64. Alternatively, following Myers (1990) and Bowerman and O'Connell (1990), a variance inflation factor (VIF) above 10 indicates the possible existence of a multicollinearity problem. In our model the maximum value was 1.57.

Heterocedasticity. The White test (White, 1980) did not reveal any problem of heterocedasticity: $n \cdot R^2 = 160 \cdot 0.29 = 46.4$, for $X^2_{34\ 0.05} = 48.7$; hence we did not reject the null hypothesis of homocedasticity.

Comparing the coefficients of the model with other studies on landscape assessment we find some common results. Zube *et al*. (1975), Daniel and Vining (1983), Knopf (1987), Orland (1988) and Purcell (1992) determine a negative relationship between man-made elements and visual quality, as we do for negative antropic elements. Furthermore, Purcell concludes that public prefer pictures highly typical with large amount of vegetation, as it occurs in our model with the percentage of vegetation. Likewise, in Dearden (1985) the presence of water and the degree of wilderness have a positive impact on the visual quality of the landscape. There are other authors that highlight the importance of water in the scene as well as the presence of trees (Ulrich, 1981; Herzog, 1985; Herzog and Bosley, 1992; Yang and Brown, 1992), in our study the effect of water on the visual quality coincides, however, the variable related to type of vegetation (herbaceous versus trees) did not result statistically significant in the regression analysis. Calatrava and Sayadi (2001, p. 270) give similar results through conjoint analysis with the percentage of vegetation as the most important attribute of the landscape, and the presence of positive antropic elements (typical Andalusian white houses in the mountains) the second. However, respondents showed a lower preference for unaltered landscape compared to agricultural fields.

We find also interesting similarities between Real *et al*. (2000) and the present paper. The former, in its first study, defines four main aspects to classify landscapes: the presence/absence of water, the artificiality of the scene, its roughness and the human presence. These four characteristics are included in the current model; this is, amount of water, degree of wilderness, horizon and the presence of positive and negative antropic elements, respectively. In the same paper, the second study presents different regression models that confirm the positive (negative) relationship between the beauty of landscape and the amount of water (amount of humanized elements).

4. Conclusions

We have implemented a straightforward method for assessing the visual quality of rural landscapes. The same methodology can be applied to other areas in order to rank and explain the scenic beauty of landscapes. The information supplied by the model can enrich the decision-making process that has to evaluate competing sites for the location of recreational facilities that will suit a given target population.

According to the results, the degree of wilderness and positively evaluated man-made features play a key role in determining the visual quality of the rural scene. These are followed by the area of water and the colour contrast. Given that man-made features are among the most important elements of the perceived visual quality of the landscape, planning the modernization of rural areas should include the impact of such features on the landscape and the possibility of using such features as a rural development tool. The other two elements that can be altered by landscape planners are the percentage of vegetation and the colour contrast. Thus, the multi-crop land allocation plus the use of natural cover between olive trees lead to a higher visual quality of the agricultural landscapes of Andalusia.

Finally, in considering the impact of the EU's Common Agricultural Policy on the landscape, we find two negative effects. The first is the reduction of crop diversity, since, as the results suggest, the greater the homogeneity of our agricultural landscape, the lower its perceived visual beauty, due mainly to the lack of colour contrast. Second, the maintenance in production of land of poor agricultural quality, as an alternative to forestry, decreases the perception of wilderness in the landscape, and thus its beauty.

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