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Farmland appraisal based on the analytic network process

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Abstract This paper presents an application of the Analytic Network Process (ANP) to farmland appraisal. The purpose of this new methodology is to solve some of the drawbacks found in comparative and capitalisation methods, called classical appraisal methods, which cannot deal with contexts where only partial information is available and/or qualitative variables are used. The ANP is a method based on the Multiple Criteria Decision Analysis (MCDA). Previous works have already applied other MCDA techniques to the appraisal context, such as the Analytic Hierarchy Process (AHP), however they have not been able to handle all the complexities of many real world appraisal problems. The ANP provides a more accurate approach for modelling complex environment because it allows the general study of the quantitative and qualitative explanatory variables of the price and the incorporation of feedback and interdependence relationships among variables. The new proposed methodology has been applied to a case study of a farm located in Valencia (Spain) in order to demonstrate its goodness. Both quantitative and qualitative variables, such as the age of the trees, productivity or water quality, have been considered to assess the market value of the farm. Six farms from the same region have been selected as reference assets. The appraisal problem has been solved in three different ways in order to study the influence of each model

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on the value of the problem farm. In this study it has been proved that the more information is incorporated into the model, the higher accuracy of the solution. From the results of this work we can conclude that the approach proposed stands out as a good alternative to current farmland appraisal approaches, as it has proven to be useful when data are only partially available, qualitative variables are used and influences among the explanatory variables are present.

Keywords Farmland appraisal · Multicriteria · AHP · ANP

1 Introduction

Asset appraisal in general, and that of farmland in particular, is an important issue in any country. Interest in the appraisal field is justified by the large number of cases where the estimation of the value of the assets is needed: sales transactions, expropriations, heritage divisions, mortgages, etc. Due to the increasing economic development of the countries and to the increasing complexity of the appraisal problems, it becomes more and more necessary to make better and more accurate valuations. To reach this end we count with several appraisal methods, called classical appraisal methods, which can be grouped into comparative methods and capitalisation methods.

Comparative methods obtain the value of the problem asset by comparison with other similar assets, namely reference assets, which should have been object of recent transactions. This analysis is based on the more significant attributes of the different assets, also called explanatory variables. Within this group of methods, the most widely used are the synthetic methods (Ballestero and Romero 1992) and the econometric methods (Murray 1969). One of the advantages of these comparative methods is their simplicity, however they require knowing the price of recent transactions of the reference assets as well as the quantification of the explanatory variables that justify this price, which is not always possible in professional practice. They present difficulties when incorporating qualitative explanatory variables.

In capitalisation methods, the price of the problem asset is determined by upgrading the future cash flows that can be generated by the asset to a present value. This involves two drawbacks, which question the objectivity of these methods: forecasting future information and determining the capitalisation rate.

Researchers, in order to find a solution to the mentioned drawbacks, have developed new alternative methods which perform well in common appraisal contexts, where only partial information is available and many qualitative explanatory variables are used. These new approaches are based on the Multiple Criteria Decision Analysis (MCDA). The expression MCDA is used as an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter (Belton and Stewart 2002).

Previous works have already applied some MCDA methods to the appraisal context. Critic method (Diakoulaki et al. 1995), Goal Programming (Charnes and Cooper 1961) and the Analytic Hierarchy Process (AHP) (Saaty 1980) have been used to determine the value of different kinds of assets, as can be consulted in Aznar and Guijarro (2004, 2006, 2007) and in Aznar and Caballer (2005). The purpose of this paper is to take a further step in the same direction of these new multicriteria-based appraisal methods by applying the Analytic Network Process (ANP) to the appraisal science, focusing on farmland appraisal as an illustration. This method was first published in Saaty (1996) and then completely revised and published in Saaty (2001) and Saaty (2006).

The rest of the paper is structured as follows. Sect. 2 introduces the ANP and then describes the new farmland appraisal approach. Sect. 3 presents a real case study for methodology validation. Finally, Sect. 4 gathers the main conclusions derived from this research and future works.

2 ANP-based appraisal approach

2.1 Background of the ANP

The AHP was proposed by Saaty in 1980 as a solution to specific decision-making problems. This method shows satisfactory results when dealing with decision problems in which a criteria hierarchical structure can be stated and independence among criteria can be assumed and proved. However, in many real world problems this independence cannot be verified. With the aim of solving this, Saaty proposed the ANP (1996), the general form of the AHP. The ANP represents any decision making problem as a network of criteria and alternatives (which are all called elements), grouped into clusters. All the elements in the network can be related in any possible way, which means that a network can incorporate feedback and interdependent relationships within and between clusters. This allows working with interdependences among criteria and provides a more accurate approach for modelling complex environments. The influence of elements in the network on other elements in that network can be represented in a supermatrix. This new concept is a two-dimensional matrix of elements by elements, which adjusts the relative importance weights in individual pairwise comparison matrices to form a new overall supermatrix with the eigenvectors of the adjusted relative importance weights. According to Saaty (2001), the ANP comprises five main steps:

(i) Conducting pairwise comparisons on the elements.
(ii) Placing the resulting relative importance weights (eigenvectors) in pairwise comparison matrices within the supermatrix (unweighted supermatrix).
(iii) Conducting pairwise comparisons on the clusters.
(iv) Weighting the blocks of the unweighted supermatrix, by the corresponding priorities of the clusters, so that it can be column stochastic (weighted supermatrix). This condition is needed to derive meaningful limiting priorities (Saaty, 2006, p.53).
(v) Raising the weighted supermatrix to limiting powers until the weights converge and remain stable (limit supermatrix).

Some of the most recent applications of the ANP to decision making problems are: prioritising and designing rule changes for the game of soccer (Partovi and Corredoira 2002), contractor selection (Cheng and Li 2004), acquisition of new machine tools in a company (Yurdakul 2004), financial crisis forecasting (Niemira and Saaty 2004), choice of best management alternative of the supply chain in a company (Agarwal et al. 2006), product mix planning (Chung et al. 2005) and evaluation of alternative fuels for residential heating (Erdoğmuş et al., 2006). Applications of the ANP to farmland appraisal have not been reported yet, so this paper tries to fill that gap in the literature.

2.2 ANP-based farmland appraisal methodology

2.2.1 Problem formulation

First, the appraiser should collect as much information as possible in order to gain sound knowledge of the appraisal problem. This information consists of: applicant and purpose of farmland appraisal, description and location of the farm to appraise and analysis of the farm environment.

2.2.2 Selection of the reference assets

The application of the ANP to farmland appraisal requires a prior adaptation of the multicriteria vocabulary to the common use appraisal terminology. This means that in appraisal context the term "criterion" is substituted by "explanatory variable" and that the "alternatives" are called the "assets taking part in the appraisal" (reference assets and problem asset).

Reference assets are similar goods to the problem asset to be compared with it in order to determine its market value. Similarity to the problem asset is a very important aspect when selecting the reference assets. They also should have been object of recent transactions and their price has to be known.

2.2.3 Selection of the explanatory variables

Explanatory variables are variables that justify or explain the price of a given asset. They correspond to the criteria in the MCDA vocabulary. Explanatory variables are chosen depending on the characteristics of the reference assets and on their similarity to the problem asset. It is necessary to have enough information about the explanatory variables of the price so that the comparison among the reference assets and the problem asset can be made.

In real farmland appraisal, only those explanatory variables which have a greater influence on the price are chosen. In this selection, the experience, the knowledge of the area as well as some indications from expert appraisers should be considered.

2.2.4 Representation of the appraisal problem as a network

The task of representing the problem as a network of interdependent elements distributed into clusters can be decomposed into three steps: (i) to identify the elements (assets and explanatory variables), (ii) to group them into clusters and (iii) to determine the influences on each other. The approximation to reality of the network will depend on the experience and knowledge of the appraiser.

2.2.5 Prioritisation of the assets using the ANP

The concept of supermatrix in the ANP will be used in order to prioritise and weight the reference assets and the problem asset. Their overall priorities can be extracted from the limit supermatrix.

2.2.6 Determination of the value/weighting ratio

In order to use the information about asset prioritisation in the field of appraisal it is necessary to obtain a ratio that compares the weight of the problem asset with its market value. This ratio can be calculated as the quotient of the sum of all the market values of the reference assets, known by the appraiser, and the sum of all their weights, obtained with the ANP.

2.2.7 Calculation of the problem asset value

The problem asset value can be calculated by multiplying the value/weighting ratio obtained in step 6 by the problem asset weight obtained in step 5. The appraiser will have to analyse if this value is reasonable and makes sense in order to decide whether to accept it or to reject it.

2.2.8 Analysis of the goodness of the result

To help in making the decision whether to accept the problem asset value obtained in the previous step or not, a ratio called suitability index (SI) (Aznar and Guijarro 2004) is proposed. This index compares the solution obtained with an appraisal approach with the one obtained when the only information known about the reference assets is their real market values. In that case, the only possible solution is to calculate the problem asset value as the mean of the real market values of the reference assets. This solution is called the naïve solution.

The suitability index is calculated as:

$$\mathrm{SI}(\%) = \left(1 - \frac{z}{z'}\right) \cdot 100 \tag{1}$$

where z is the sum of the absolute deviations between the real market values of the reference assets and the values obtained with the ANP approach solution and z' is the sum of the absolute deviations between the real market values of the reference assets and the values obtained with the naïve solution.

A high value of the SI, i.e. close to 100%, means that the proposed ANP approach is better than the naïve solution, because in that case z is smaller than z'. This index is useful when comparing different appraisal approaches.

3 Case study

3.1 Problem formulation

The information shown in Table 1 corresponds to seven farms located in the municipality of Carlet (Valencia, Spain). The market values of farms A to F are known due to recent transactions. The aim is to estimate the market value of farm X, which is the problem farm. The information about characteristics of the farms was gathered in a recent visit to the farms.

All the farms have peach trees planted and they have a very similar area. The age of the trees of the farms is known, however this information has to be transformed because what influences on the farm price is not that age but the years of productive life which are left (life expectancy of peach trees is estimated in 25 years in the region). The productivity is the capacity of the farm to generate income given its current agricultural condition. Since the quantitative information related to this parameter is not available, it has been expressed with a verbal scale. The type of irrigation is trickle in all farms. Microclimate is a very important qualitative attribute because it has a great influence on productivity: mild climates and low risks of frost are more preferred. The access to the farm, which is good in all farms, measures

Table 1 Characteristics of the farms

Farm	A	B	C	D	E	F	X
Value (€/ha)	37,000	55,000	30,000	27,000	46,000	35,000	Unknown
Crop	Peach	Peach	Peach	Peach	Peach	Peach	Peach
Area (ha)	0.50	0.60	0.35	0.90	1.00	1.10	0.80
Age of the trees (years)	8	10	9	16	13	5	8
Productivity	Good	Excellent	Good	Normal	Good	Normal	Very good
Type of irrigation	Trickle	Trickle	Trickle	Trickle	Trickle	Trickle	Trickle
Microclimate	Good	Good	Normal	Normal	Normal	Good	Very good
Access to the farm	Good	Good	Good	Good	Good	Good	Good
Water quality	Normal	Normal	Normal	Good	Very good	Normal	Normal
Soil quality	Good	Good	Good	Good	Good	Good	Good
Prospects	None	None	None	None	None	None	None

the ease of entering in the plot. The water quality refers to aspects such as mineral salts content or pollution presence, which directly influence on quantity and quality of productivity. The soil quality refers to the pedological characteristics of the soil, which happen to be good in all farms. Finally, the term "prospects" is used to consider any possibility, in short or mid-term, that the farm is transformed into an urban plot, because of its proximity to a metropolitan area or to an industrial park, but there are no prospects for these farms.

As shown in Table 1, the information to solve this appraisal problem is not very accurate. Although there are two quantitative explanatory variables (area of the farm and age of the trees), the rest of variables are expressed in a qualitative way. This is because some explanatory variables are difficult to quantify, such as microclimate, or because more specific information was not available, for example for productivity. This appraisal context, where qualitative explanatory variables are used and only partial information is available, presents difficulties when using classical appraisal methods and justifies the use of a multicriteria method, such as the ANP.

3.2 Selection of the reference assets and the explanatory variables

Farms A to F have comparable agronomic characteristics to those of farm X, as shown in Table 1, and their price is known due to recent transactions. Thus, all farms A to F will be used for comparison with the problem farm X.

When selecting the explanatory variables, we have to take into account only those with remarkable differences among the farms, because the differences in the explanatory variables justify the differences in the price. In Table 1 we can see that the farms do not show differences in the type of crop, type of irrigation, access to the farm, soil quality and prospects. Although they have different area, this variable has not been considered because the authors assumed that the unit price is independent from the size of the farm. Therefore, in the price determination, the only explanatory variables that will be taken into consideration will be the age of the trees, productivity, microclimate and water quality, and we shall call them EV_1, EV_2, EV_3 and EV_4 respectively.

3.3 Resolution of the appraisal problem

The appraisal problem has been solved in three different ways in order to study the influence of each model on the value of the problem farm. In the first two models it has been solved with ANP and in model 3 with AHP. We will use the suitability index to compare the three solutions.

3.3.1 Model 1

Model 1 is the simplest network we can build (Fig. 1). It consists of two clusters: one of explanatory variables and one of assets (six reference assets plus the problem asset). The two-sense arrow between clusters means mutual influence. On one hand, explanatory variables influence on farm value. The appraiser must assign an importance weight to the explanatory variables in order to measure how much each explanatory variable influences on the price of a given farm. The assignment of weights can be done by means of pairwise comparison matrices formation. On the other hand, farm prices influence on explanatory variables. This means that when comparing two farms with respect to a given explanatory variable, the best ranked one should have the highest price and therefore the appraiser will assign to it the biggest weight. The assignment of weights can be done in a direct way, if quantitative information is available, or by pairwise comparison matrices formation, when there is only qualitative information.

When all the influences in the network have been analysed and all the relative importance weights have been assigned, the unweighted supermatrix can be built. The unweighted supermatrix corresponding to model 1 network is shown in Table 2. As the network is formed by two clusters, and there is no feedback within clusters, the supermatrix shown in Table 2 is already stochastic by columns, so the unweighted supermatrix coincides with the weighted supermatrix. Raising the weighted supermatrix to limiting powers, until the weights have converged and remain stable, we obtain the limit supermatrix, which is shown in Table 3. Overall priorities of the farms can be extracted from Table 3 and these data can be used to calculate the value of farm X (Table 4). NOTE: All the values that appear in the following Tables (2–12) have been rounded.

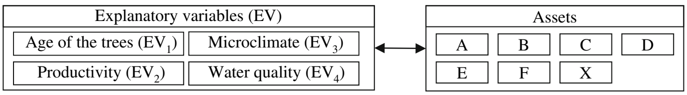

Fig. 1 Model 1 network

Table 2 Unweighted/weighted supermatrix in model 1

		EV				Assets						
		EV_1	EV_2	EV_3	EV_4	A	B	C	D	E	F	X
EV	EV_1	0	0	0	0	0.522	0.151	0.560	0.167	0.096	0.375	0.152
	EV_2	0	0	0	0	0.200	0.635	0.250	0.167	0.250	0.125	0.390
	EV_3	0	0	0	0	0.200	0.151	0.095	0.167	0.096	0.375	0.390
	EV_4	0	0	0	0	0.078	0.063	0.095	0.500	0.558	0.125	0.068
Assets	A	0.160	0.096	0.151	0.077	0	0	0	0	0	0	0
	B	0.142	0.409	0.151	0.077	0	0	0	0	0	0	0
	C	0.151	0.096	0.059	0.077	0	0	0	0	0	0	0
	D	0.085	0.039	0.059	0.218	0	0	0	0	0	0	0
	E	0.113	0.096	0.059	0.397	0	0	0	0	0	0	0
	F	0.189	0.039	0.151	0.077	0	0	0	0	0	0	0
	X	0.160	0.225	0.370	0.077	0	0	0	0	0	0	0

Table 3 Limit supermatrix in model 1

		EV				Assets						
		EV_1	EV_2	EV_3	EV_4	A	B	C	D	E	F	X
EV	EV_1	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127
	EV_2	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169
	EV_3	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
	EV_4	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
Assets	A	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
	B	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
	C	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
	D	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
	E	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074
	F	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
	X	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106

Table 4 Calculation of the problem farm value in model 1

Farm	Supermatrix weight	Normalised weight	Value (€/ha)	Ratio	Ratio × normalised weight of X
A	0.060	0.121	37,000	292104.28	62,104
B	0.111	0.222	55,000		
C	0.049	0.098	30,000		
D	0.044	0.089	27,000		
E	0.074	0.149	46,000		
F	0.054	0.109	35,000		
X	0.106	0.213			

Table 5 Calculation of the suitability index in model 1

Farm	Value (€/ha)	Ratio × weight	|Difference|	Farm	Value (€/ha)	Mean	|Difference|
A	37,000	35,301	1,699	A	37,000	38,333	1,333
B	55,000	64,820	9,820	B	55,000	38,333	16,667
C	30,000	28,695	1,305	C	30,000	38,333	8,333
D	27,000	25,922	1,078	D	27,000	38,333	11,333
E	46,000	43,493	2,507	E	46,000	38,333	7,667
F	35,000	31,769	3,231	F	35,000	38,333	3,333
	Model deviation (z) = 19,641				Naïve deviation (z′) = 48,667		
	Suitability index (SI) = (1 − z/z′) × 100 = 59.64%						

The value of farm X obtained in model 1 is 62,104 €/ha. We can compare this solution with the naïve solution, by means of the SI, in order to measure the goodness of this result. Table 5 presents how to calculate the SI in model 1.

3.3.2 Model 2

One of the main advantages of the ANP is the possibility it offers to incorporate interdependence relationships among explanatory variables. This fact, which is not possible in the hierarchical structure of the AHP, provides a more accurate approach for modelling complex appraisal context. Figure 2 shows the network of model 2. The arrow over the cluster of explanatory variables represents a feedback within this cluster. This is because the age of the

Table 6 Unweighted supermatrix in model 2

		EV				Assets						
		EV_1	EV_2	EV_3	EV_4	A	B	C	D	E	F	X
EV	EV_1	0	0.109	0	0	0.522	0.151	0.560	0.167	0.096	0.375	0.152
	EV_2	0	0	0	0	0.200	0.635	0.250	0.167	0.250	0.125	0.390
	EV_3	0	0.582	0	0	0.200	0.151	0.095	0.167	0.096	0.375	0.390
	EV_4	0	0.309	0	0	0.078	0.063	0.095	0.500	0.558	0.125	0.068
Assets	A	0.160	0.096	0.151	0.077	0	0	0	0	0	0	0
	B	0.142	0.409	0.151	0.077	0	0	0	0	0	0	0
	C	0.151	0.096	0.059	0.077	0	0	0	0	0	0	0
	D	0.085	0.039	0.059	0.218	0	0	0	0	0	0	0
	E	0.113	0.096	0.059	0.397	0	0	0	0	0	0	0
	F	0.189	0.039	0.151	0.077	0	0	0	0	0	0	0
	X	0.160	0.225	0.370	0.077	0	0	0	0	0	0	0

Table 7 Weighted supermatrix in model 2

		EV				Assets						
		EV_1	EV_2	EV_3	EV_4	A	B	C	D	E	F	X
EV	EV_1	0	0.055	0	0	0.522	0.151	0.560	0.167	0.096	0.375	0.152
	EV_2	0	0	0	0	0.200	0.635	0.250	0.167	0.250	0.125	0.390
	EV_3	0	0.291	0	0	0.200	0.151	0.095	0.167	0.096	0.375	0.390
	EV_4	0	0.155	0	0	0.078	0.063	0.095	0.500	0.558	0.125	0.068
Assets	A	0.160	0.048	0.151	0.077	0	0	0	0	0	0	0
	B	0.142	0.205	0.151	0.077	0	0	0	0	0	0	0
	C	0.151	0.048	0.059	0.077	0	0	0	0	0	0	0
	D	0.085	0.020	0.059	0.218	0	0	0	0	0	0	0
	E	0.113	0.048	0.059	0.397	0	0	0	0	0	0	0
	F	0.189	0.020	0.151	0.077	0	0	0	0	0	0	0
	X	0.160	0.113	0.370	0.077	0	0	0	0	0	0	0

Table 8 Limit supermatrix in model 2

		EV				Assets						
		EV_1	EV_2	EV_3	EV_4	A	B	C	D	E	F	X
EV	EV_1	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127
	EV_2	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146
	EV_3	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146
	EV_4	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.117
Assets	A	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
	B	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
	C	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
	D	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
	E	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
	F	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
	X	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100

Table 9 Calculation of the problem farm value in model 2

Farm	Supermatrix weight	Normalised weight	Value (€/ha)	Ratio	Ratio×normalised weight of X
A	0.059	0.126	37,000	293266.17	63,266
B	0.079	0.170	55,000		
C	0.044	0.095	30,000		
D	0.048	0.103	27,000		
E	0.076	0.165	46,000		
F	0.058	0.125	35,000		
X	0.100	0.216			

Table 10 Calculation of the suitability index in model 2

Farm	Value (€/ha)	Ratio×weight	|Difference|	Farm	Value (€/ha)	Mean	|Difference|
A	37,000	37,024	24	A	37,000	38,333	1,333
B	55,000	49,975	5,025	B	55,000	38,333	16,667
C	30,000	27,745	2,255	C	30,000	38,333	8,333
D	27,000	30,220	3,220	D	27,000	38,333	11,333
E	46,000	48,369	2,369	E	46,000	38,333	7,667
F	35,000	36,667	1,667	F	35,000	38,333	3,333
	Model deviation (z) = 14,559				Naïve deviation (z′) = 48,667		
	Suitability index (SI) = (1 − z/z′)×100 = 70.08%						

Table 11 Priorities of the farms with AHP (model 3) and calculation of the problem farm value

Farm	EV_1	EV_2	EV_3	EV_4	Priorities	Value (€/ha)	Ratio	Ratio×priority of X
	0.347	0.087	0.419	0.147				
A	0.160	0.096	0.151	0.077	0.139	37,000	303260.02	73,260
B	0.142	0.409	0.151	0.077	0.159	55,000		
C	0.151	0.096	0.059	0.077	0.097	30,000		
D	0.085	0.039	0.059	0.218	0.090	27,000		
E	0.113	0.096	0.059	0.397	0.131	46,000		
F	0.189	0.039	0.151	0.077	0.143	35,000		
X	0.160	0.225	0.370	0.077	0.242			

Table 12 Calculation of the suitability index in model 3

Farm	Value (€/ha)	Ratio×weight	|Difference|	Farm	Value (€/ha)	Mean	|Difference|
A	37,000	42,029	5,029	A	37,000	38,333	1,333
B	55,000	48,302	6,698	B	55,000	38,333	16,667
C	30,000	29,346	654	C	30,000	38,333	8,333
D	27,000	27,179	179	D	27,000	38,333	11,333
E	46,000	39,641	6,359	E	46,000	38,333	7,667
F	35,000	43,503	8,503	F	35,000	38,333	3,333
	Model deviation (z) = 27,423				Naïve deviation (z′) = 48,667		
	Suitability index (SI) = (1 − z/z′)×100 = 43.65%						

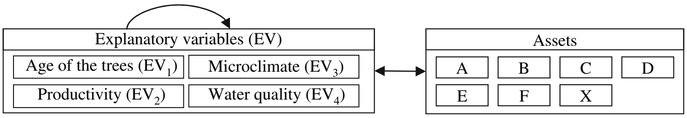

Fig. 2 Model 2 network

trees, microclimate and water quality have a clear influence on the farm productivity. The appraiser should measure the influence of these explanatory variables on productivity with an importance weight, which can be assigned again by pairwise comparison matrix formation. All the relationships that were analysed in model 1 are also present in model 2, so we can keep that information for this model.

The unweighted supermatrix in model 2 is shown in Table 6. If we assume that feedback and assets have the same influence on the cluster of explanatory variables, the corresponding weighted supermatrix is Table 7. When raising this supermatrix to limiting powers the limit supermatrix can be obtained (Table 8). Calculation of the problem farm value is shown in Table 9 and calculation of the suitability index in this model is presented in Table 10.

The value of farm X obtained in model 2 is 63,266 €/ha. Its SI is 70.08%.

3.3.3 Model 3

We will now solve the appraisal problem with the AHP. Figure 3 shows the corresponding hierarchy. The evaluation of the farms with respect to each explanatory variable is the same as in previous models. The difference between the hierarchy and the network is that in the hierarchy the weights assigned to the explanatory variables to measure their influence on the price of the farms are unique, while in the network it is possible to assign different weights for each farm. If the appraiser fixes the weights for EV_1, EV_2, EV_3 and EV_4 as 0.347, 0.087, 0.419 and 0.147, respectively, Table 11 shows the corresponding priorities of the farms. With all these data the value of farm X can be calculated. Calculation of the suitability index in model 3 is shown in Table 12.

The value of farm X obtained in model 3 is 73,260 €/ha. Its SI is 43.65%.

3.4 Determination of the end value of the problem asset

It has been proved that the three models presented are better than the naïve solution. The best model is model 2 (ANP with feedback, SI = 70.08%) and model 3 (AHP, SI = 43.65%) is the worst one. Therefore, we can conclude that the more information is incorporated into the model, the higher suitability index is obtained. The appraiser must decide the end value of farm X, depending on the approach to reality desired.

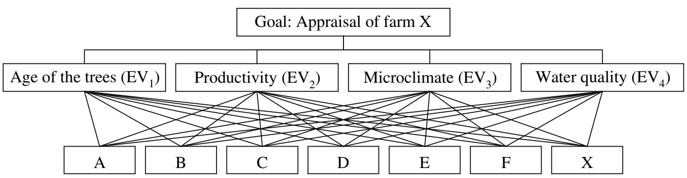

Fig. 3 Model 3 hierarchy

4 Conclusions

In this paper a multicriteria method, namely the ANP, has been applied to farmland appraisal. It has proven to be especially useful when data are only partially available, qualitative variables are used and influences among the explanatory variables are present. These situations present difficulties when applying classical farmland appraisal methods or preceding multicriteria methods, so the methodology proposed seems to improve previous works and stands out as a good alternative to current farmland appraisal approaches. Moreover, it can be adapted to any kind of assets, provided the explanatory variables and reference assets be correctly identified.

Beyond the scope of this work is the formulation of more complex networks, containing more interdependent elements and clusters, to more accurately estimate the value of the problem farm.

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