How to deal with competing types of nature and agriculture in the same area: A case study on Spanish olive groves

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Abstract

In this paper the Analytic Hierarchy Process (AHP) multicreteria evaluation method has been used to evaluate 4 different competing management options at olive plantations (*Olea europaea* L.) in mountain areas. All the evaluation process is integrated into a Geographical Information System (GIS) that gave possibility to allocate each of the options geographically. The results suggested that area currently occupied by conventional olive farming should be restructured as (% of area occupation): 35.8% to conventional olive farming, 23.3% to integrated olive farming, 19.1% to organic olive farming and 22.8% transformed to natural use as a Mediterranean forest in order to increase the social welfare of the society.

Keywords: Olive plantations, AHP, GIS, land use optimisation.

Introduction

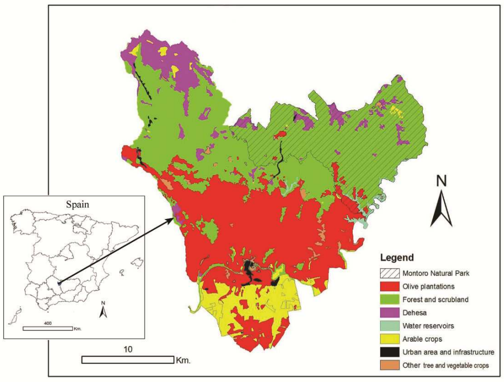
The competition of different land uses in the same area is a frequent issue in human landscapes. Agricultural uses are not an exception. In the present study, four competing and equally valid alternatives are evaluated for the land currently occupied by conventional olive farming: i) keeping the current conventional olive farming; ii) integrated olive farming; iii) organic olive farming; iv) restoration of the Mediterranean forest. Thus the main aim of this study is the olive grove (*Olea europaea* L.) landscape in Southern Spain (Municipality of Montoro, Andalucía). Three of the four alternatives mentioned are for agricultural use and one (restoration of the Mediterranean forest) represents nature restoration in areas currently under agricultural use. The main objective of the study is to provide a proposal for the organization of the study area, allocating the alternatives considered according to evaluation criteria.

The evaluation of the four alternatives is carried out through the Analytic Hierarchy Process (AHP) multicriteria decision-making technique (Saaty, 2003). The evaluation in the frame of the AHP method is carried out from economic, social and environmental perspectives, taking into account objective information regarding the situation of the area. Additionally, the use of Geographical Information System (GIS) technology in raster format allows each of the four alternatives to be allocated in the area under study.

Area of study

The Municipality of Montoro, located in the province of Cordoba in southern Spain (Figure 1), represents a variety of agricultural ecosystems (pasture, olive groves and annual crops) with forest/shrub natural vegetation near agricultural areas. Its 58,103 hectares are divided into olive plantations (34.2%), arable crops (8.1%), forest (17.5%), scrubland (28.7%), *dehesa* and other pastures (8.7%), water reservoirs (1.1%), urban area and infrastructure (0.8%) and other land uses (0.9%).

Fig 1. Study area map



Most of the olive plots have less than 2 hectares, thus presenting a highly fragmented agricultural landscape that makes it more difficult to implement any policy measures. Most of the olive groves do not use vegetal covers between the trees, which aggravates the soil erosion problem in steep slope areas and reduces the ecological value of the system.

This study area is particularly interesting due to its proximity to the Natural Park of "Sierra de Cardeña y Montoro", home of some endangered species like the Iberian lynx which is the most important of them. The study is also an example of the transition from intensive agriculture to extensive agricultural production systems.

Methods

As a frame methodology the Analytic Hierarchy Process is used at the study. The method belongs to the family of multicriteria decision-making techniques (Forman and Selly, 2001). The principal interest of this method lies in the possibility of measuring as tangible so relatively intangible commodities during the decision-making process and hierarchical structuring of the decision making problem (Saaty et al., 2003). The measurement of the different objectives is obtained *via* pair-wise comparisons between all of them (Saaty, 2008). A review of applied studies that have employed this technique can be found in Vaidya and Kumar (2006).

Since the AHP method is applied to the area under study its use is coupled with the use of GIS technology. Empirical studies that have used multicriteria evaluation methods for the solution of spatial problems include that of Carver (1991) and later Malczewski (1999) which brought together two approaches developed much earlier: Multi-Attribute Utility Theory (MAUT) and the use of GIS as a platform for representing the spatial dimension of the problems. A large number of studies have since adopted this approach, including Thirumalaivasan et al. (2003), Ayalew et al. (2005), Strager and Rosenberger (2006), and Neaupane and Piantanakulchai (2006).

Following AHP frame, mentioned above, a complex hierarchy was constructed consisting of 5 levels (Figure 2). Level 1 represents a main objective of the study. Level 2 represents 3 main evaluation criteria from which the area is analysed. Level 3 represents hierarchical disaggregation of the three main evaluation criteria of level 2 and level 5 represents four alternatives. Levels 1, 2, 3 and 5 are common to all AHP problems (evaluation criteria & alternatives). Level 4 represents the inclusion of the territorial dimension of the analysis. At this level five territorial models are obtained to assess either the potential or risk of the olive plantations with respect to the functions demanded by Society.

Results

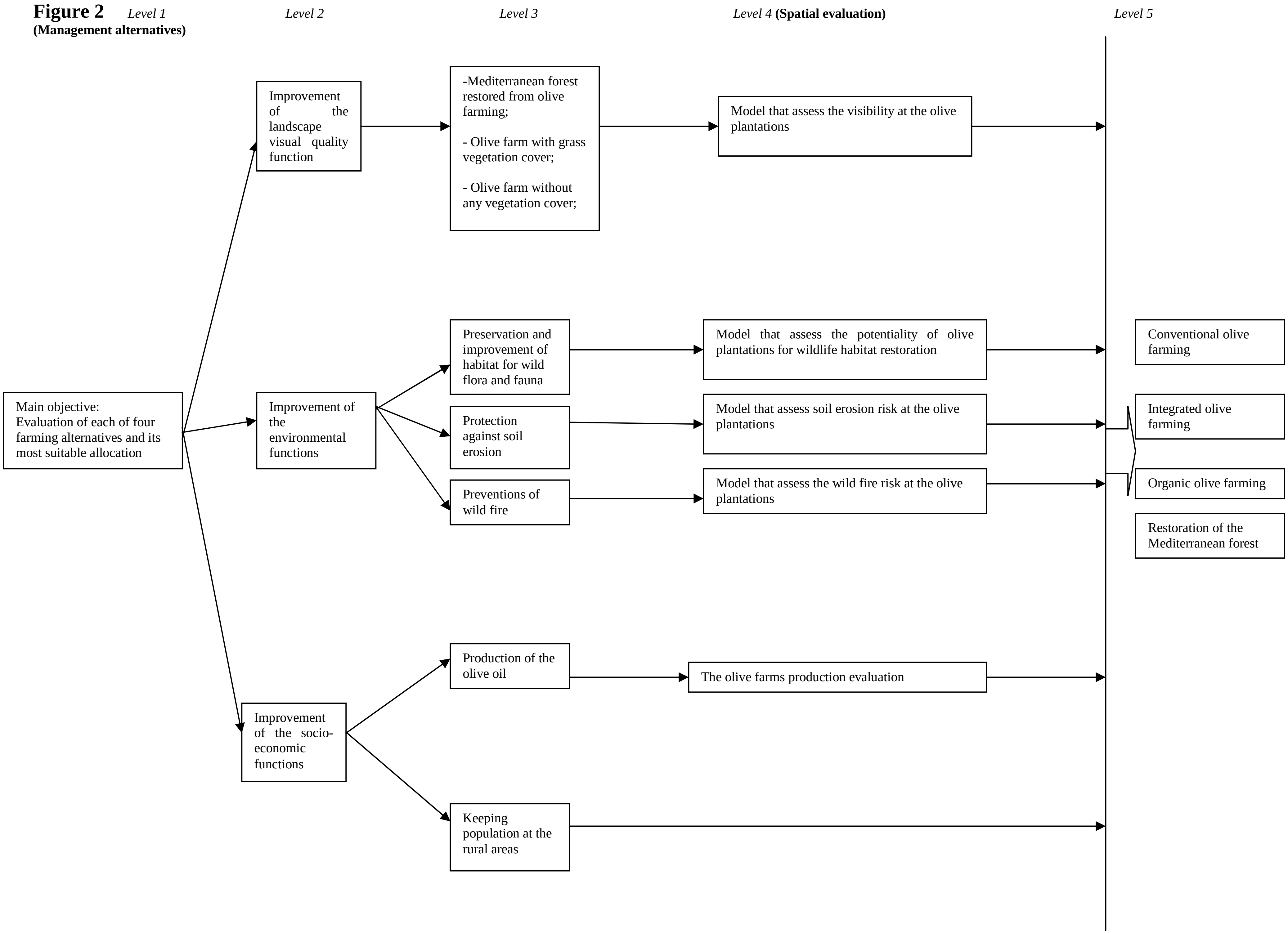
A total of 480 citizens were interviewed following a structured questionnaire with AHP pair-wise comparison of the selected functions of the olive plantations (level 2 and 3 at the Figure 2). The results obtained are in the table 1.

Table 1. Social preferences of the functions of the olive plantations in mountain areas

Socio-economic functions (42.5%)	Keeping population in rural areas	24.2%
	Production of olive oil	18.3%
Environmental functions (42.2%)	Wildfire prevention	17.1%
	Soil erosion prevention	16.2%
	Wildlife and flora habitats improvement	8.9%
Provision of quality agricultural landscape (15.3%)	Olive plantations with vegetal cover between trees	6.4%
	Olive plantations colonized by Mediterranean vegetation	6.2%
	Olive plantations without vegetation between lanes	2.7%
	Total	100.0%

Source: Survey on social preferences carried out in Cordoba (Spain) with 480 personal interviews.

Figure 2


Level 1
(Management alternatives)
Level 2
Level 3
Level 4 (Spatial evaluation)
Level 5
Main objective: Evaluation of each of four farming alternatives and its most suitable allocation
Improvement of the landscape visual quality function
Improvement of the environmental functions
Improvement of the socio-economic functions
-Mediterranean forest restored from olive farming;
- Olive farm with grass vegetation cover;
- Olive farm without any vegetation cover;
Preservation and improvement of habitat for wild flora and fauna
Protection against soil erosion
Preventions of wild fire
Production of the olive oil
Keeping population at the rural areas
Model that assess the visibility at the olive plantations
Model that assess the potentiality of olive plantations for wildlife habitat restoration
Model that assess soil erosion risk at the olive plantations
Model that assess the wild fire risk at the olive plantations
The olive farms production evaluation
Conventional olive farming
Integrated olive farming
Organic olive farming
Restoration of the Mediterranean forest

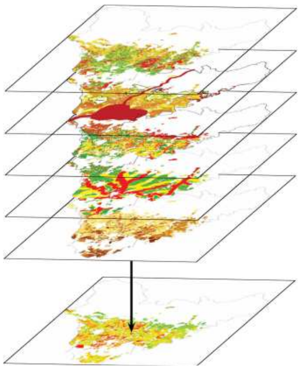
Consequently 5 territorial models were elaborated:

- Model that assesses the visibility at the olive plantations;
- Model that assesses the potentiality of olive plantations for wildlife habitat restoration;
- Model that assesses soil erosion risk at the olive plantations;
- Model that assess the wild fire risk at the olive plantations;
- The olive farms production evaluation;

Some of them are complex studies and are published as separate studies (Nekhay et al., 2009a; Nekhay et al., 2009b) for models on potentiality for wildlife habitat restoration and soil erosion risk respectively, others are much more simple (like olive farms production evaluation) and represent a reclassification of the olive area according to the production records. Two remaining territorial models (assessment of the visibility and assessment of the wild fire risk at the olive plantations) are not published as separate studies but are studies done following the rigorous suggestions of the existing literature.

After that a weighted aggregation of 5 territorial models was performed (Figure 3). The weights are retrieved from the table 1.

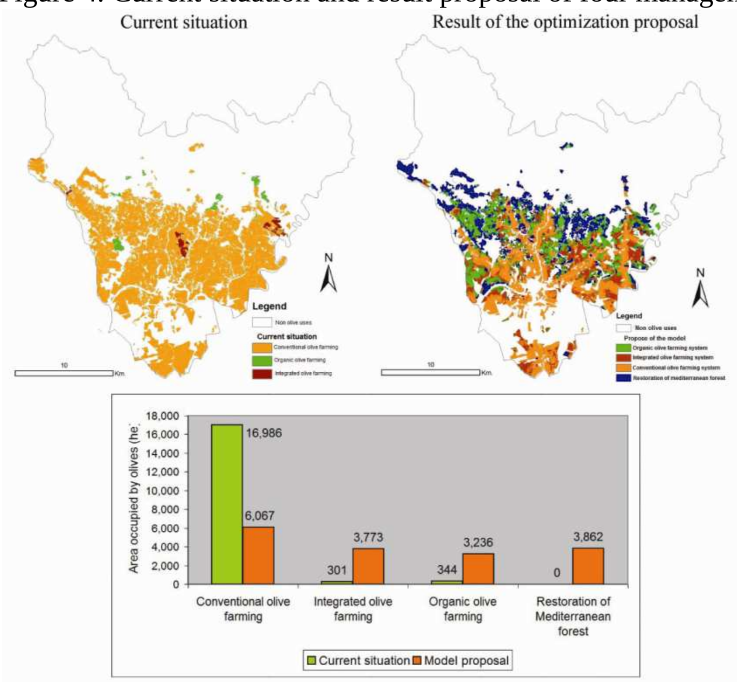
Figure 3. Weighted aggregation of 5 territorial models.



Source: own elaboration

The results (Figure 4) of geographical allocation of four considered alternatives (% of area occupation) shows that 35.8% need to be dedicated to conventional olive farming, 23.3% to integrated olive farming, 19.1% to organic olive farming and 22.8% transformed to natural use as a Mediterranean forest.

Figure 4. Current situation and result proposal of four management alternatives allocation



Source: own elaboration

Conclusions

The population survey shows that socio-economic and environmental functions are the most important function (42% each).

The geographical allocation of each of the four alternatives proposed indicates that two thirds of the conventional production system should shift toward integrated and organic production systems and the restoration of the Mediterranean forest to maximize social welfare.

The proposed changes would result in a higher level of social welfare due to the positive effects of the prevention of soil erosion, the expansion of endangered species' habitats and the preservation and improvement of the flora and wildlife in general. In addition, the higher ecological diversity improves the visual quality of this agricultural system.

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