Spatial multicriteria decision analysis to potential beekeeping assessment. Case study: Montesinho Natural Park (Portugal)

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Abstract

The Multicriteria decision analysis is a tool to support decision-making in the identification of areas with the utmost beekeeping potential. This paper design a GIS multicriteria approach to assess the beekeeping potential. The development of a conceptual model structure requires the participation of stakeholders and experts in that process. The spatial Multicriteria Decision Analysis (MCDA) allowed defining the potential beekeeping map. The resulting maps can be used by the beekeepers associations to easily select the more suitable areas for the apiaries location or relocation and avoid prohibited areas by legal requirements.

Keywords: Beekeeping, GIS, Montesinho Natural Park, Multicriteria decision analysis.

1   Introduction

The beekeeping plays an important role within the rural areas because the hive products offer an additional income to the populations [1].

The beekeeping planning is greatly affected by spatial factors; therefore Geographical Information System (GIS) are a powerful tool to overlap and relate a variety of spatial data levels on a map, and consequently a very useful tool for beekeeping activity planning.

The GIS have been applied in a sparse beekeeping planning research studies [1, 2, 3]. The implementation of spatial analysis models based on GIS [3] resulted in a set of variables important to the beekeeping planning.

Multicriteria decision analysis (MCDA) can be defined as a group of methods and procedures for evaluating decision alternatives based on multiple conflicting criteria which aids in the selection of the best alternative. The effort to integrate MCDA into GIS has been contributory for developing the paradigm of spatial decision support, in which geographic information technology is made available directly to decision-makers for policy or scenario development [4].

The main purpose of this paper is to propose a methodology to assess the beekeeper potentiality using GIS and multicriteria analysis.

2   Data and Methods

This work defines a methodology to assess the potential beekeeping activity in the Montesinho Natural Park (Figure 1) a region in the northwest of Portugal, managed by a beekeeper association. The area has 75,000 hectares with an enormous diversity of vegetation. The altitudes range from 1486 meters


Figure 1: Location of study area.
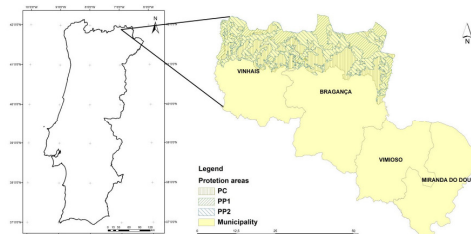
in the Montesinho Mountain and 438 meters in the Mente river (Douro basin).

The spatial multicriteria model is supported by the following spatial data: land use, Digital Terrain Model (DTM), river network, water body, road network; urban areas, sources of electromagnetic radiation, climatic variables, and apiary location.

The land use data (COS2007) was provided by the Direção-Geral do Território (DGT) and is a vector map with highly thematic detail. The DTM was produced by spatial interpolation of the altimetry data. The map of the radiation received by the terrain was based on the DTM. The river network, road network and urban areas were extracted from the topographic map and aerial images, and were subject to proximity analysis to obtain the map of distance for these features. The electromagnetic radiation (communication towers and electric power transmission network) was provided by the national authorities. The temperature and precipitation maps were extracted from [5].

The survey of the geographic location of the apiaries (Figure 2) was accomplished by a Global Positioning System (GPS), Trimble Juno 5 Series. The field work also allowed collecting information about the existing flora nearby the apiaries.
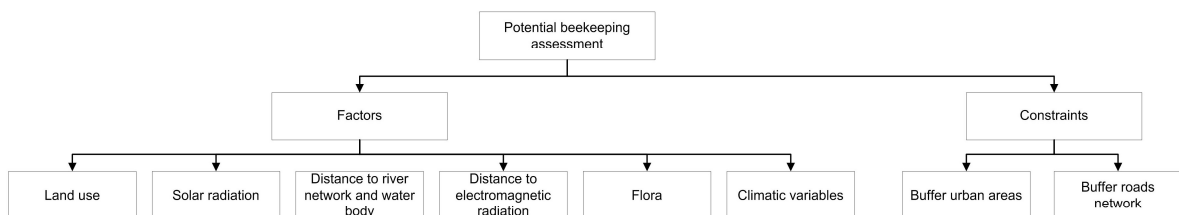
Figure 2: Location of the apiaries.
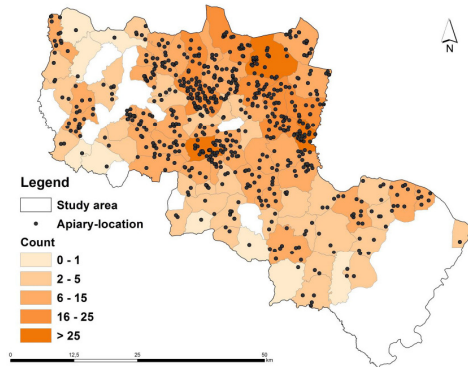
The GIS-MCDA is a process that transforms and combines spatial data and value judgments into a final decision [4] allowing for a better understanding of their multi-components.

The criterion is one of a number of measures against which options are assessed and compared in the multicriteria analysis [6]. The structure of the proposed model which allowed the identification of criteria that reflect the beekeeping potential was classified as factors or constraints (Figure 3). A factor is a measure that enhances or detracts from the suitability of a specific alternative for the activity under analysis. In this case, the factors are: land use, solar radiation, distance to river network and water body, distance

to sources of electromagnetic radiation, temperature, precipitation and flora in the apiaries vicinity. A constraint serves to affect or restrict the alternatives under consideration; it is an element or feature that represents limitations or restrictions and whether an area is considered unsuitable. This study uses legal constraints to affect the beekeeping potential (Figure 4).

The methodological process has the following steps: (1) hierarchical structure of the beekeeping potential model; (2)

Figure 4: Legal constraints to beekeeping.
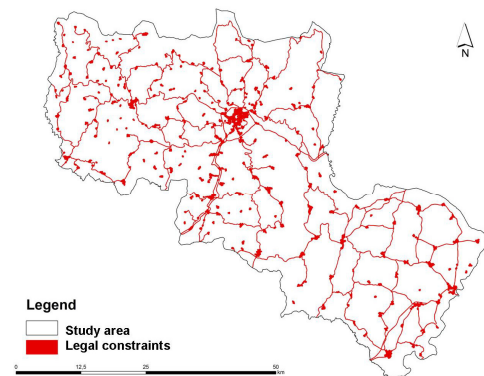
standardisation of the criteria; (3) criteria weighting; (4) decision rules; and (5) mapping of beekeeping potential.

The criteria were measured on different scales, so factor values must be standardised before combination. The standardisation, typically, uses the minimum and maximum value as scaling points. This process uses a range of fuzzy set membership functions to convert the criteria values into another comparable scale, expressing a fuzzy standardised scale of values.

The purpose of assigning weights to the criteria is to express the degree of importance of each factor in relation to others in the evaluation process, and it is a challenge step in the decision-making process. The relative weight of the vulnerability criterion is estimated by the Analytic Hierarchy Process (AHP) a method originally developed by Saaty [7]. The AHP compares criteria pair wise and then computes overall relative weights based on aggregate calculations of all pair wise ratios [8].

The criteria weighting process was established by the judgments, according the following assumptions: (1) the

Figure 3: The factors and constraints to potential beekeeping assessment.

differentiation of the criteria relative importance considered by a panel of experts, and (2) the empirical knowledge of bee masters. In this case, Weighted Linear Combination (WLC) was used to combine the criteria and produce the potential beekeeping map.

3   Results and discussion

In the surrounding areas of urban areas and roads, apiaries can't be installed due to legal framework. The constraints map obtained taking into account legal requirements is shown in Figure 4.

After the criteria aggregation was possible the creation of a beekeeping potential map (Figure 5) with a continuous scale range classified into five equal interval classes.

Figure 5: Map of beekeeping potential.
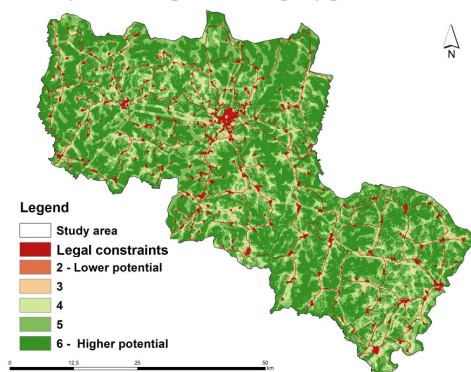
These results provide a framework, which may help policy makers, planners, beekeepers association, and bee masters to improve the beekeeping activity.

In the study area 60% of the apiaries are located in high potential areas and the remaining apiaries should be relocated to improve the beekeeping activity.

Acknowledgments

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