BEEKEEPING ACTIVITIES PLANNING WITH GIS METHODOLOGIES

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Abstract
Correct beekeeping activities planning with Geographic Information System (GIS) methodologies seems essential to improving efficiency and productivity. There are distinct problems related to bee mortality, namely climate conditions, diseases, surrounding flora, water availability, legal distances to roads and residential areas, and others.
Spatial analysis allows for overlap and relates various levels of information on a map, so it can be an important tool for beekeeping activity planning.
The mapping construction, with all its important information, allows for the current distribution and status of apiary sites on protected areas where beekeeping is permitted to be known, as well as the disease incidence and the productivity and quality in different years.
This work developed a model to produce maps with potential areas for beekeeping activity by combining a choice of data sources: vegetation, land use, topography, water resources, roads and access paths and disease.
The model was tested in a selected area in the central region of Portugal.
The Digital Elevation Model is produced by spatial interpolation of altimetry data. The insolation map was calculated by overlaying the following rasters: viewshed, sunmap and skymap to calculate diffusion and direct radiation received from each areal direction.
The roads and water resources were extracted from topography maps, and then the proximity analysis was applied to obtain the distance classes of these features. The spatially distributed vegetation cover is obtained from the land use classes. The maps were integrated in the GIS to be used in both management and analysis of the territory.
A first identification of the apiaries allowed for the establishment of potential beekeepers' zones and also planning for future apiary installation.
It was also verified that the zones identified in the beekeeper planning map as poor for apiculture presented a higher focus of diseases.

Key words: beekeeping; GIS; planning; potential beekeepers' zones

Introduction

Beekeeping is an important activity in the rural development and economy in Portugal. Moreover, pollinators, namely bees, are also vital to agriculture. They play a significant role in crop production and are essential partners in the success of agriculture (Gallai et al, 2009). Effective beekeeper activities, conservation and management in a region, is generally based on bee species, habitat characterization, targeted approaches, ecological data, landscape scale of dynamic and interconnected habitats capable of delivering bee conservation in the

context of global environmental change (Murray et al, 2009). On the other hand, the Geographic Information Systems (GIS) are a very important tool for planning and land management. They also help decision makers to improve effective and correct decisions and designs.

In order to have better profitability in this important activity, which depends on natural resources, it becomes important to develop tools and mechanisms for planning, management and decision-making for beekeeping work.

Some works have been done on the subject of spatial beekeeping planning using GIS methodologies in order to create models to support decision making (Maris et al, 2008; Lidónio et al, 2010; Anjos et al, 2010; Amiri et al, 2011; Roque, 2011; Amiri et al, 2012; Marques et al, 2012; Anjos et al, 2013: Roque et al, 2013; Fernadez et al, 2013). Moreover, it is necessary to perform more studies to introduce additional data and test new methodologies to create a powerful tool to support beekeeper activity.

According to Anjos et al (2013) and Fernadez et al (2013), the overlapping of different sources of information with GIS identifies areas with beekeeping potential, illegal areas and zones with lower beekeeping potential. According to these authors the GIS simulate scenarios which allow apiary repositioning to identify well the geographic location that complies with the legal requirements. Information produced in the form of thematic mapping is a management tool of beekeeping.

This work applies the model developed by Anjos et al (2013) and Fernadez et al (2013) that produce maps with the potential areas for beekeeping activity by combining a choice of data sources: vegetation, land use, topography, water resources, roads and access paths and disease, in Santo André in the central region of Portugal (Castelo Branco).

Material and Methods

Santo André with an area of 7485 is located in Castelo Branco District. More precisely, the area is located between the latitude of 39,7° and 39,8°N and longitude -7,7° and -7,6°W (Figure 1). Due to its floral diversity and climatic conditions, this site is considered as a good place for apiculture activities.

The mean altitude of the site is 412 m above sea level and the mean annual temperature is about 16.2 ^{0}C (average of last three years). The mean long term precipitation in the last 3 years has been recorded as 833 mm.

Castelo Branco region has important water resources (Ocreza river, Alvito stream and Magueija stream) that has always been linked to different economic activities of the residents, including mills, work with flax, olive mills and agro-pastoral economy. The richness of the fauna in this region is due to the diversity of the ecosystems. It is possible to find forests, woods, ponds, mountains, rivers and prairies. Many different species, some rare or even in danger of extinction can be found here. The Ocreza river is the main important water resources of Santo André das Tojeiras.

The study area, Santo André das Tojeiras is a parish of the district of Castelo Branco, with 7487,4 ha of area and 747 habitants.

The landscape of the region is predominantly Mediterranean, where it is possible to find species like *Quercus rotundifolia*, *Quercus suber* and *Quercus coccifera*. Along the water lines, *Sambucus nigra*, *Buckthorn alnus*, *Salix salvifolia*, *Crataegus monogyna*, *Almus glutinosa*, *Fraxinus augustifolia* and *Arbutus unedo* are common species. The most representative shrub species are *Lavandula spp.*, *Cytisus striatus*, *Ulex europeus* and *Pterospartum tridentatum*.

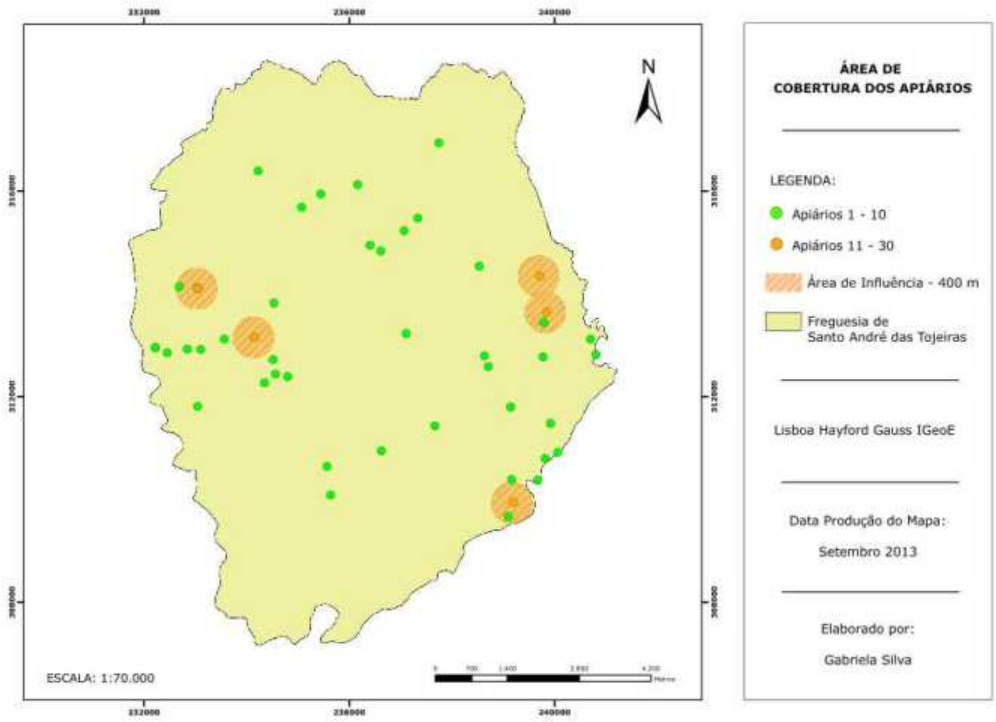

Figure 1. Geographical position of the studied area.

The study was developed in the reference system PT-TM06/ETRS89 - European Terrestria - Reference System 1989. The transformations for the reference system were performed according to the method of grids NTv2 developed by Gonçalves (2010). The grids in the format NTv2 allow conversion between multiple data sites used in Portugal and datum ETRS89. The transformation grids have an RMSE of 9 cm in the case of datum Lisbon (Gonçalves, 2010, Fernandez et al., 2013).

The data methodology analysis was developed by Anjos et al (2013) and Fernadez et al (2013). This methodology is the geographical information integration of the following maps into a database: land use, hydrography, topography, roads and access paths and human settlements.

The apiaries were geographical referenced through a Global Positioning System (GPS).

In each apiary the following information was collected: beekeeper reference, apiary number, number of hives, available water resources, information about available vegetation resources and proximity of pollution sources.

The information about bee diseases of in three consecutive years was collected from the regional beekeeping association.

With all available spatial information thematic mapping was developed to represent the beekeeping potential in the study area.

The final beekeeper conflict map was in accordance with the Portuguese standards (Diário da República, N^{o}. 277, Series I - A, 2005) which regulates the minimum distances between apiaries.

According to Wolf et al. (2006) the distance from apiary to water must not be greater than 500 m in order to minimize the energy and time consumption to collected water. In this work we considered the recommended distances to the water lines as 500 m as reported by other authors (Lidónio et al, 2010; Anjos et al, 2010; Marques et al, 2012; Anjos et al, 2013; Fernadez et al, 2013).

The spatial analysis procedures were performed in the program ArcGIS 10 - ArcInfo with the extensions Spatial Analyst and 3D Analyst.

Results and discussion

To create a map of land occupation which interests beekeeping, the Portuguese land occupation map (COS'2007) for level 2 (PGI 2010) was used.

For the map construction the classes of occupation/land use with beekeeping interest namely forests, scrub, arborous vegetation, inland water and heterogeneous agricultural areas (Figure 2) were selected.

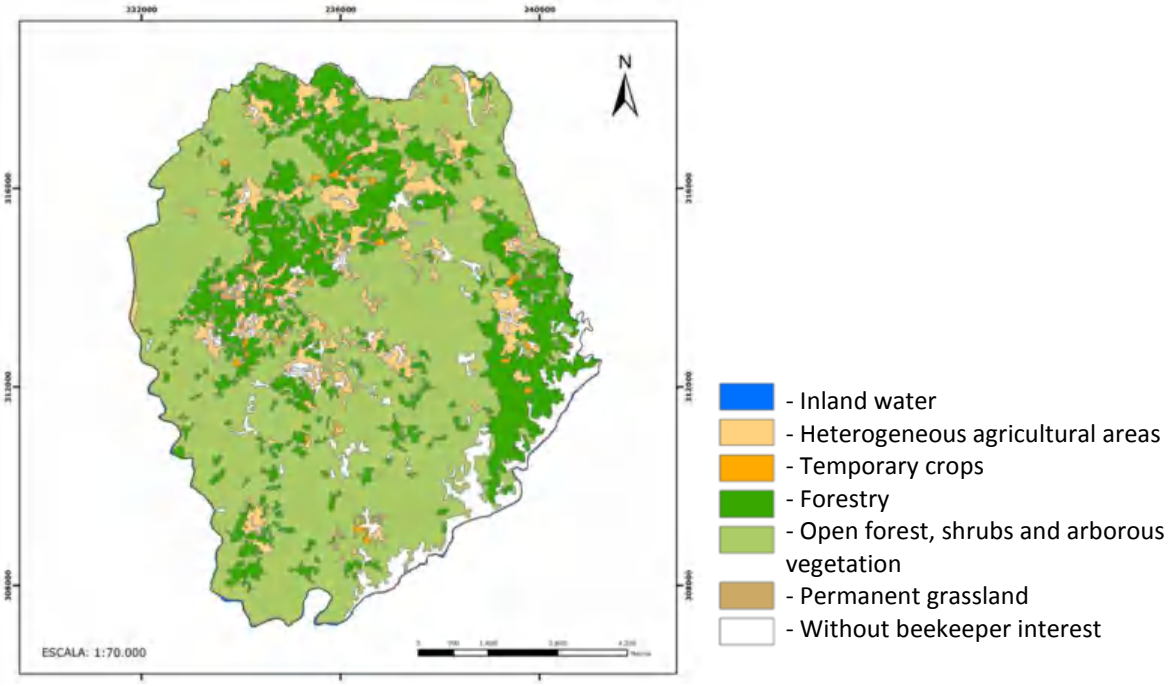

Figure 2 - Letter of land occupation reclassified to the study area

To assess the number of apiaries, which do not respect the minimum legal distance, a map of apiaries conflicts considering the distances reported in the standard was made. There are only 4 apiaries which do not respect the legally areas. This location could be easily corrected with the support map of beekeeping potential.

Figure 3 represents the map of beekeeping potential with the zone legally interdict to beekeeping activity and apiaries in the study region. 32 % of total area has beekeeping potentiality for the selected condition and only 8% of total area represent legally interdict zone to beekeeping activity. These results confirm the interest of this region to beekeeping activity.

Seven of the identified apiaries are installed in zones unsuitable for beekeeping. With the support of this map it was possible to proceed with the repositioning of the apiaries for a more suitable zone for this practice, with the advantage of a better and higher honey production. On the other hand, during the installation of new apiaries it is easy to select the best locations. With the use of GIS tools it is possible correctly plan the location of apiary installation and management.

Figure 4 represents the diseases occurring in apiaries (varroose and nosemose).

Because the apiaries are in a controlled zone, when a disease was found rapid action is taken for hive treatment. It was observed that the Apiaries with an identified disease has

decreased over the years and some of the reported diseases are in the interdict zones or in zones identified as inappropriate for beekeeping.

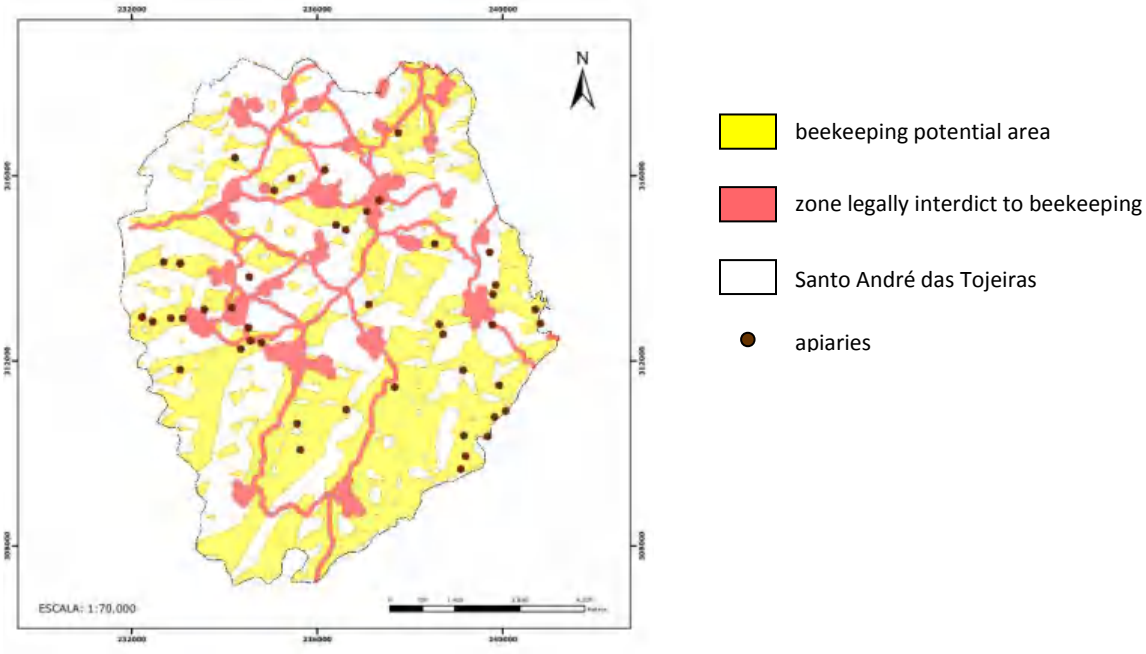

Figure 3 – Map of beekeeping potential with zone legally interdict to beekeeping activity and apiaries.

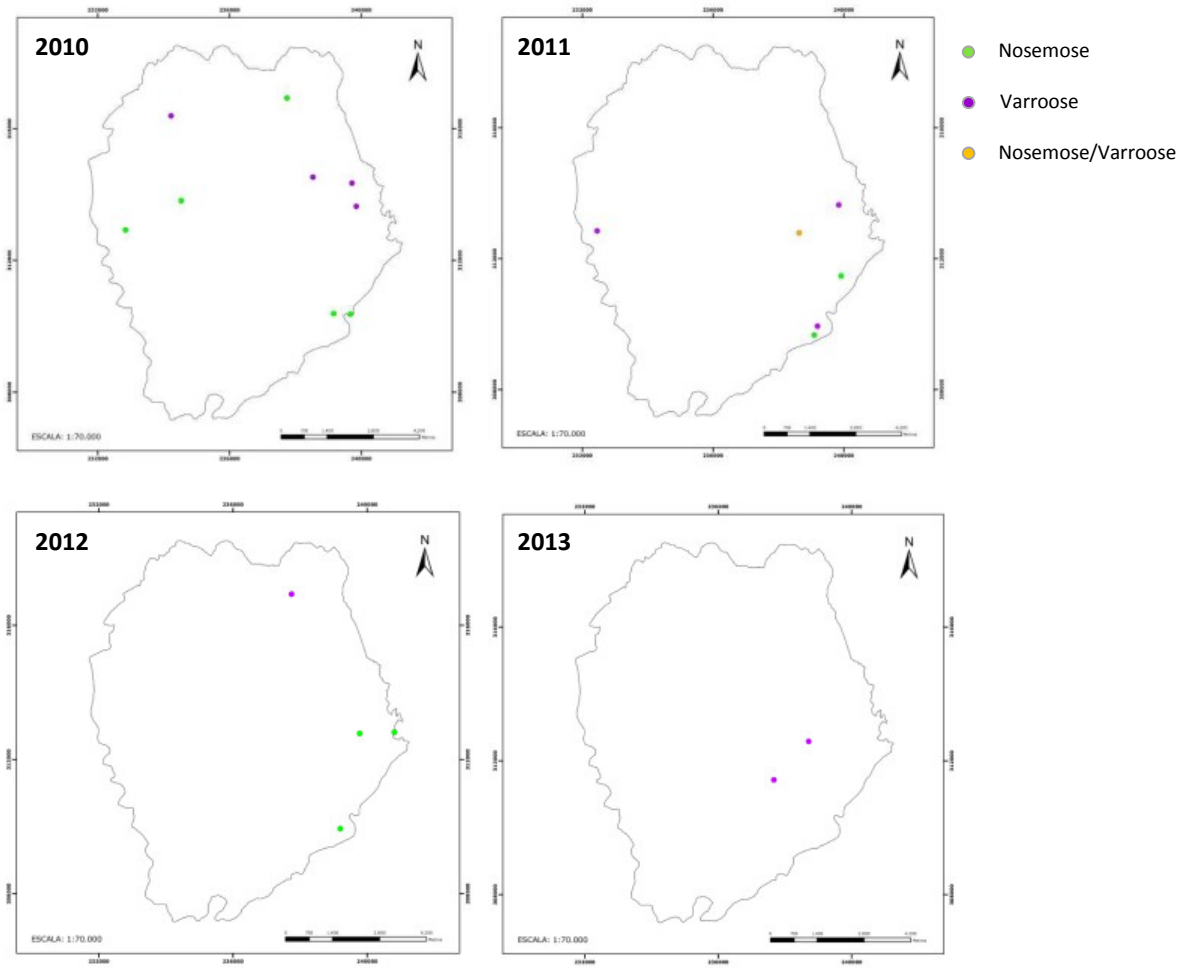

Figure 3 – Map of beekeeping potential with zone legally interdict to beekeeping activity and apiaries

Conclusion

This study allowed for the creation of a map of potential beekeepers' zones and also provides a tool for planning future apiary installation.

It was also verified that the zones identified in the beekeeper planning map as poor for apiculture, presented a high focus of diseases.

Information produced in the form of thematic mapping is an important management tool for beekeeping activity.

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