Land evaluation of suitability for the practice of foot orienteering using a spatial multicriteria method. A case study in the central eastern region of continental Portugal

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ABSTRACT

Orienteering is a sport in which the orienteer completes a course of control points in the shortest possible time, aided only by a map and compass, involving the choice of itineraries, through reading and interpreting the map and its relationship with the terrain. The most important factors for selecting areas for orienteering are difficult and challenging terrain that enables good course setting. Finding a suitable area for foot orienteering involves multiple criteria. The main features that provide the athlete greater opportunities for testing navigation skills are, among others, a detailed representation of the terrain, containing rich landforms, and its cover, since foot orienteering is a sport organized in forests or natural areas. Based on these principles, this study aims to assess the suitability of the Central Eastern Region of Continental Portugal for the practice of Foot Orienteering. The suitable areas and their constraints were identified based on integrating a set of criteria using multicriteria spatial analysis tools in a GIS environment. For this purpose, the following descriptors were integrated: land cover, slope, slope variation, Topographic Position Index (TPI), and aspect variation. The criteria were classified into four levels of suitability, calculated by applying the Hierarchical Analytical Process. Based on the results obtained by the proposed methodology, we concluded that 52.5% of the study area presents high suitability for foot orienteering at a competitive level. That is a notable potential resource for the advancement of the sport, and for further refinement of the presented methodology based on additional data and criteria.
Keywords: Land cover, Multicriteria analysis, Foot orienteering, Suitability, Terrain modelling.

INTRODUCTION

Orienteering maps are detailed maps specially designed with the intention of supporting the competitor in the navigation, allowing them to locate the control points in the terrain and to decide which is the ideal route (Aires et al., 2011). The usual way to determine if a terrain is suitable for orienteering is through field control by an expert (Darken & Banker, 1998). The factors considered are steepness, the density of vegetation, run ability, and the frequency of changes in the terrain (Tutić et al., 2018, Petrovic, 2009). A pre-selection of suitable terrains for orienteering can reduce the time and costs involved in the process. Tutić et al. (2018) proposed a spatial multiple-criteria decision-making approach to determine areas suitable for Foot Orienteering in Croatia and Slovenia. The authors used criteria like terrain slope, slope variation, aspect, aspect variation, and land cover. Another criterion widely used in studies of terrain characterization is the Topographic Position Index (TPI), which detects distinct slope positions and landforms (Fabian, 2004). The present study aims to analyse the land suitability for the practice of Foot Orienteering in the Central Eastern part of Continental Portugal (NUTS: Médio Tejo, Alto Alentejo, and Beira Baixa). For that purpose, a multicriteria spatial analysis tool - the Analytical Hierarchical Process (AHP) in a GIS environment was used, integrating different biophysical factors.

MATERIAL AND METHODS

Data collection and processing
The datasets used in the study were EU-DEM for the terrain model and COS 2018 for the Land Use Land Cover (LULC) information. A spatial database was created in ArcGIS 10.8 software. From EU-DEM, the layers slope, slope variation, aspect variation, and TPI were calculated using 3D analysis tools. All layers were classified into four levels of suitability for Foot Orienteering.

Analysis
The Analytic Hierarchy Process (AHP) was performed by combining all weighted spatial layers (Saaty, 1987). The AHP process was completed by validating the consistency of the pairwise comparison.

RESULTS

The maps resulting from the spatial analysis and geoprocessing in order to perform the AHP, as well as the range of values obtained, are: Land Use Land Cover (9 classes), Slope (0 to 62.01%), Slope Variation (-53.21 to 394.89), Topographic Position Index - TPI (-189.81- to 111.50) and Aspect Variation (-314.55 to 323.24). The criteria values from terrains with existing orienteering maps used for high-level competitions with values of the spatial neighbourhood between the 5th and 95th percentile of the distribution are the following: Slope (0 to 33.96%), Slope Variation (-7.44 to 22.75), TPI (-19.59- to 57.75) and Aspect Variation (-233.47 to 205.23). For LULC, the land cover data in the COS 2018 dataset is on a nominal scale (distinct land cover classes), and the analysis was performed using local operators. The values of the criteria obtained for the areas with orienteering maps were considered in the presented classification. As a result of the application of the AHP, the mapping of the overall suitability of terrain for Orienteering events was obtained, with 7367.19 km², corresponding to 52.5% of the territory, having high potential for the practice of Foot Orienteering. The municipalities with the greatest potential for the practice of Foot Orienteering and, consequently are Ponte de Sôr (2.77 ± 0.50), Gavião (2.69 ± 0.51), and Abrantes (2.68 ± 0.55), with 38.2% of the total municipalities having a suitability level above 2.5 on a scale of up to 3. The value of the consistency ratio (RC) obtained was 0.03. Assuming, therefore, the existence of a good consistency in the pairwise comparison of the matrix.

DISCUSSION

The hypothesis that there are new terrains suitable for high-level Orienteering events, and that can be identified through multicriteria spatial analysis, is proven by applying the proposed methodology to the case study. Those conclusions corroborate those obtained by the other known study in which a multicriteria spatial approach was performed to identify areas that meet criteria suitable for Foot Orienteering (Tutić et al., 2018). The innovative aspect of the investigation carried out consists, in addition to being the first of its kind to be carried out in Portugal, in the fact that the TPI was introduced in the analysis. This methodology reduces time and costs in the process of selecting new terrains for Orienteering and helps the ongoing development of the sport with its benefits for participants and society and aims to the filling of the gap in the literature concerning studies in this field.

CONCLUSIONS

Based on the results obtained by the proposed methodology, we can conclude that the studied region has a high potential for the practice of Foot Orienteering in more than half of its territory. This is a remarkable potential resource for the development of this sport. Greater detail in the base information, more specifically in the LULC survey (e.g., the density of shrub cover, the network of rural roads) will allow obtaining additional criteria regarding run ability by the athletes, an important factor in determining suitability for Foot Orienteering. There are also other factors that can influence the final choice of new land to map, namely the restrictions in land access, frequency of changes in use, and existing risks.

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