Chapter 12
Spatial Planning of Nature Sports in Cross-Border Regions With a Focus on Orienteering

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ABSTRACT

As a growing sector, tourism has become a significant contributor to the global economy and has the potential to promote economic growth and development in many regions. Nature sports tourism can be an important aspect of tourism and can have significant economic, social, and cultural impacts on the host communities. Nature sports activities and events are usually integral to tourism market planning. Hosting sporting events has become a key strategy for destinations to gain recognition and is often included in their event portfolios for annual tourism planning. Using events to mitigate seasonality and diversify tourist flows is a common objective, as it can contribute to the local visitor economy and enhance the overall viability of the destination. As the popularity of outdoor events continues to grow, it is important to understand the environmental consequences of outdoor events and to implement sustainable practices. Addressing environmental sustainability is, therefore, a crucial aspect of nature sports tourism planning. This chapter focuses on a particular nature sport—orienteering. The most important factor for selecting areas for orienteering is the difficulty of a challenging terrain that enables a 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 Tejo/Tajo International Transboundary Biosphere Reserve for practicing 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 suitability levels and calculated using the Hierarchical Analytical Process. The impact of orienteering activities on the natural values existing in the Tagus/Tajo International Transboundary Biosphere Reserve was also assessed, with particular emphasis on the impact on vegetation and wildlife.

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INTRODUCTION

Today, sports and leisure habits are increasingly turning to the natural environment for their practice, as is the case of Orienteering. Also, there is greater awareness of the need for sustainable use of natural resources. The big challenge will be reconciling the demand line (of spaces to practice orienteering) with the supply line (of natural spaces and their quality).

Orienteering maps are specially designed to support competitors in navigation, allowing them to locate the control points in the terrain and decide which is the ideal route to them. Maps must be detailed, showing all the major terrain features that influence the competitors' decision on the fastest route to the next control point (Aires et al., 2011).

The usual way to determine if a terrain is suitable for orienteering is through field control by an expert, allowing an assessment of the terrain for setting challenging courses containing rich landforms and land features (Darken & Banker, 1998). Besides these main criteria for setting challenging courses, other factors such as access to the terrain, distance to the traffic network, steepness, density of vegetation, runability, and the frequency of changes in the terrain, are also considered (Tutic et al., 2018, Petrovic, 2009).

Organizers and mapmakers typically use large-scale topographic maps, local knowledge, or random reconnaissance of terrain when looking for new terrains for orienteering events. A good pre-selection of suitable terrains for orienteering can reduce the time and relatively high costs involved in making orienteering maps.

Tutic et al. (2018) proposed a multiple-criteria decision-making approach applied to a GIS-based land suitability evaluation to determine areas that meet topographic and land cover criteria suitable for Foot Orienteering in Croatia and Slovenia. In the proposed methodology the authors used specific, 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). The TPI is an algorithm characterized by its ability to detect distinct slope positions and landforms based on the difference in elevation between a central pixel and its neighbouring pixels (Fabian, 2004).

Sports and physical activities can be an important aspect of tourism and can have significant economic, social, and cultural impacts on the host communities. However, they also have significant environmental impacts, particularly outdoor events. As the popularity of outdoor events continues to grow, it is important to understand the environmental consequences of outdoor events and to implement sustainable practices. Addressing environmental sustainability is therefore a crucial aspect of event tourism planning and management (Ruhanen et al., 2019).

Outdoor events like orienteering must, therefore, pay extra attention to sustainable management to prevent and mitigate potential environmental damage, especially in the physical environment. Orienteering, by its very nature and by additional procedures of good practice, is a sport of low ecological impact. However, the most significant environmental effects related to nature as trampling of vegetation, disturbance of large mammals, and disturbance of birds (Parker, 2005). Marion et al. (2016) adds that especially high visiting numbers during an event can lead to vegetation impact, impact on soil, littering, erosion, or impact on wilderness.

Parker (2005) concluded from the general vegetation impact studies that he reviewed that orienteering, for events with up to approximately 2500 participants, has a very low impact on vegetation, with rapid recovery. For very large events, there is more significant general vegetation impact with sometimes an additional growing season or part season necessary for full recovery to be achieved at the more heavily used sites within the competition terrain. However, long-term damage to vegetation was not reported

in the different studies, including those events with very large entries of 10,000 or more. Therefore, concerning general vegetation impact, the perception that orienteering does cause significant long-term damage is not correct. However, there may be localized areas of more sensitive vegetation sites, such as marshes and lichen-covered rock. The protection of such areas is normally secured by standard planning procedures that route courses away from them or ensure that carrying capacities are not exceeded.

Subsequently, Mendoza (2007) conducted a long-term study monitoring the impacts of an Orienteering event in Canada in 2002 for the following three years (2002 to 2005). After the competition, the impacts were considered negligible. However, two months after the competition, the impacts were categorized as significant, with trampling causing bark removal in some branches, leading to vegetation death. By the end of the third year, there was no evidence of area impact due to the competition.

In Portugal, studies conducted by Campos (2001) and Quinta-Nova & Cardoso (2013) evaluated the impacts on flora and vegetation of an international event - the Portugal 'O' Meeting 2001 - held in the Peneda-Gerês National Park. The authors selected and characterized thirteen areas before and after the event, concluding that the effects were of reduced magnitude and significance, with a brief impact on the time of permanence and restoration of initial conditions.

In terms of impacts on the animal populations, the studies on the impact of orienteering events show evidence of very low impact on larger mammals and that if orienteering is conducted following established environmental procedures for mammals, it is concluded that, for practical purposes, the perception that the sport is damaging to fauna is unlikely. The observations showed that most species returned to normal within their usual territories within 24 hours (Huddart & Stott, 2019). Also, no evidence exists of significant long-term effects on birds caused by Orienteering events. The post-event surveys found no change in activity or number or territories of this species. (Huddart & Stott, 2019). However, some bird species are sensitive to human disturbance (e.g., black stork, imperial eagle, Bonelli's eagle), so their breeding range can be highly restricted by human presence. Those species with a high conservation status and with an area of occurrence are restricted to full protection areas, where recreational and sporting activities are not permitted.

The present study aims to address different aspects of sustainable planning of Orienteering events in the Portuguese part of the Tejo/Tajo International Transboundary Biosphere Reserve, Castelo Branco, Portugal. For that purpose, a multicriteria spatial analysis tool - the Analytical Hierarchical Process (AHP) in a Geographical Information System (GIS) environment was used, integrating different biophysical factors of the territory to produce suitability maps. Also, the more sensitive areas of the region were identified to respect its carrying capacity, with particular emphasis on the impact on vegetation and wildlife.

MATERIALS AND METHODS

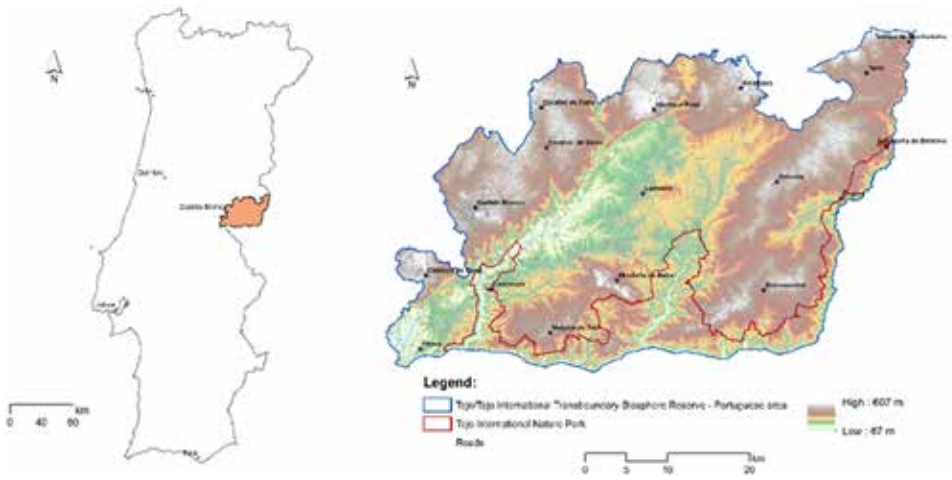
The Study Area

The study area located in the central-eastern part of Portugal, includes the Tejo International Nature Park (PNTI) and the surrounding area belonging to the Tejo/Tajo International Transboundary Biosphere Reserve, with an extent of 1,692 sq. km (Fig. 1). It is an area of low altitude but with steep relief as a result of the embedding of the Tagus and its tributaries on the edge of the peneplain. Most of the veg-

etation is made up of sclerophyllous formations of holm oak and cork oak, as well as abundant patches of scrub, which alternate with cultivated areas and pasture.

The PNTI is recognized as an important area for bird species protected by international conventions. In the Park area are also present several plant communities typical of Mediterranean ecosystems classified as priority habitats by the EU Habitats Directive. The climate is typical Mediterranean, sub-humid to dry, with mild winters and warm summers. The annual mean precipitation is about 600 [mm yr-1], with peaks in autumn and winter.

Figure 1. Location of the study area



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. First, a spatial database was created in ArcGIS 10.8 software to include all vector and raster layers and data models. Areas of existing orienteering maps were vectorized as polygons, creating a mask of reference areas. The spatial layers were prepared, and the consistency of coordinates was maintained. From EU-DEM, the layers representing different proprieties extracted from the terrain, namely 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.

The spatial data sets for the study were obtained from the following sources:

- Land Cover map - COS 2018 (DGT, 2024).
- Official Administrative Map of Portugal - CAOP 2022 (DGT, 2024).
- Protected Areas and Natura 2000 Network maps (ICNF, 2024).
- Copernicus Digital Elevation Model (DEM) for Europe (ESA, 2024).

Multicriteria Analysis

The Analytic Hierarchy Process (AHP) was performed to determine the suitability for Foot Orienteering by combining all weighted spatial layers. The AHP decomposes a problem, question, or decision, in all the variables that constitute it, in a scheme of criteria and then makes pairwise comparisons between them (Saaty, 1987). The pairwise comparison matrix was created using a scale of 1-9 to determine the relative importance of each criterion, involving the consultation of different Orienteering experts. The AHP process is completed by validating the consistency of the pairwise comparison. If the consistency ratio (RC) < 0.1, there is consistency in the pairwise comparison matrix.

Selection of the criteria that will have a direct influence on the facility in question. As can be expected, many different factors can be considered in spatial studies, and those selected will follow the required objectives, the information available, the planner's experience, etc. In this study, all the criteria are reflected in the corresponding GIS layers (Table 2)

Table 1. Factors considered in the determination of terrain suitability for foot orienteering

Criteria	Relevance
Land Use Land Cover	Land cover is one of the most important criteria since foot orienteering is an activity organized in forests or natural areas.
Slope	Too flat terrains tend to be less physically and technically challenging. Too steep terrains can be dangerous and physically too demanding.
Slope variation	Variation in terrain slope means that the terrain probably has more important features for setting a challenging course.
Topographic Position Index	This index helps to distinguish topographic features such as a hilltop, valley bottom, exposed ridge, flat plain. Features that are important for setting challenging courses.
Aspect variation	Variation in the terrain aspect means that the terrain probably has more landforms that are important for setting challenging courses.

The Analytical Hierarchy Process (AHP) consists of four essential phases: criteria generation, spatial analysis, standardization, and suitability assessment.

First, a spatial database was created to include all vector and raster layers and data models. All spatial layers were prepared, and the consistency of coordinates was maintained in ArcGIS 10.8 software. All criteria included in the analysis had to be standardized. Standardization makes all spatial layers constant and in the same measurement units' format (Saaty, 1980). Hence, all vector layers were converted into raster format and the reclassify tool in ArcGIS was used to standardize and assign values for each criterion.

The AHP decomposes a problem, question, or decision in all the variables that constitute it in a scheme of criteria and sub-criteria and then makes pairwise comparisons between them (Satty, 1987).

The pairwise comparison matrix was created using a scale of 1-9 to determine the relative importance of each criterion, in which 1 had equal importance and 9 had extreme importance between the two criteria shown in Table 2.

Table 2. Saaty's scale for pairwise comparison

Numerical rating	Scale	Interpretation
1	Equal importance	Two criteria contribute equally to the objective
3	Moderate importance	Judgments slightly favour one criterion over another
5	Strong importance	Judgments strongly favour one criterion over another
7	Very strong importance	A criterion is favoured very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favouring one criterion over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals	Opposites	Used for inverse comparison

After generating all pairwise comparison matrices, the vector of weights is calculated according to Saaty's eigenvector method. This is followed by two steps to calculate weights: First, normalizing the pairwise comparison matrix. Then, the weight for each criterion is computed.

In the suitability assessment stage, the weighting linear combination approach produces a composite suitability map. All spatial layers were converted into raster models and the reclassify tool was employed to classify all layers to a standardized measurement suitability scale between 1 and 3, where 1 indicates less suitable while 3 denotes the most suitable. The weighted overlay technique was performed to combine all weighted spatial layers and produce the ecotourism suitability map, using the GIS-based AHP extension developed by Marinoni (2004). The technique statistically is implemented by calculating the composite suitability value (E_{ij}) for each pixel (ij) as follows:

$$E_{ij} = \sum W_k S_{ijk} \quad (1)$$

Where w_k is the assigned weight for criteria k while S_{ijk} is the standardized value of pixel (ij). The values of S_{ijk} range between 1 and 3.

Constraints on Orienteering Practice

To identify the constraints on Orienteering practice in the study area, the most sensitive areas were identified, namely the locations with more sensitive vegetation and higher conservation status, as well as the areas most susceptible to soil erosion.

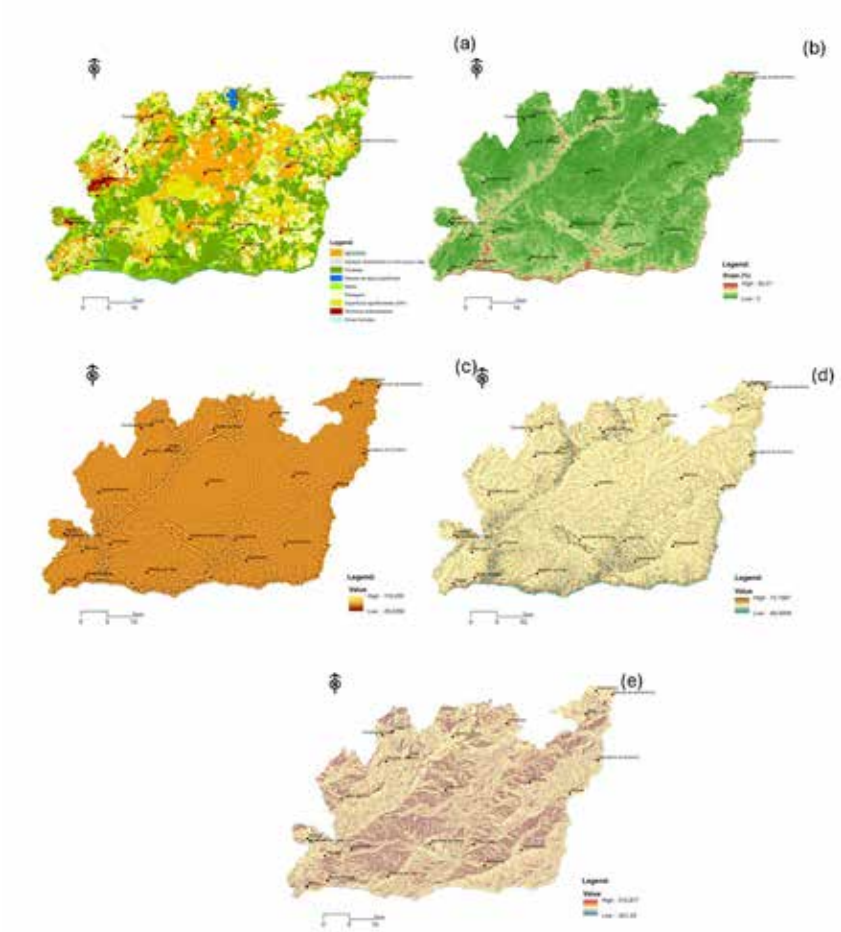
From a nature conservation perspective, the protection classes defined in the International Tejo Natural Park were considered, where no activities will be allowed in the total protection zone, as well as the special protection zones integrated into the Natura 2000 Network, due to the presence of vegetation and wildlife species more vulnerable and with high conservation status.

Areas with the highest susceptibility to erosion resulting from excessive trampling were also identified. For this purpose, areas with a slope greater than 16% were delimited based on EU-DEM using 3D analysis tools.

RESULTS AND DISCUSSION

Figure 2 presents the maps resulting from the spatial analysis and geoprocessing of the datasets corresponding to each criterion.

Figure 2. Cartography of criteria: a) Land Use Land Cover; b) Slope; c) Slope Variation; d) Topographic Position Index; e) Aspect Variation



Once the required maps are calculated, the next step was to define the criteria values from terrains with existing orienteering maps used for national and international events held in the Central Eastern part of Continental Portugal - NUTS III: Médio Tejo, Alto Alentejo, and Beira Baixa in the last 5 years, and obtained from the Portuguese Orienteering Federation (Figure 3). Then, these criteria values are applied to the whole area, giving filtered required maps for multicriteria evaluation. For the slope, slope variation, TPI, and aspect variation layers, this is accomplished by considering a high suitability level to 25x25m cells with values of the spatial neighborhood between the 5th and 95th percentile of the distribution of this value in the reference terrains. For LULC, the land cover data in the CORINE data set is on a nominal scale (distinct land cover classes), and the analysis was performed using local operators.

Figure 3. Reference terrains for Orienteering

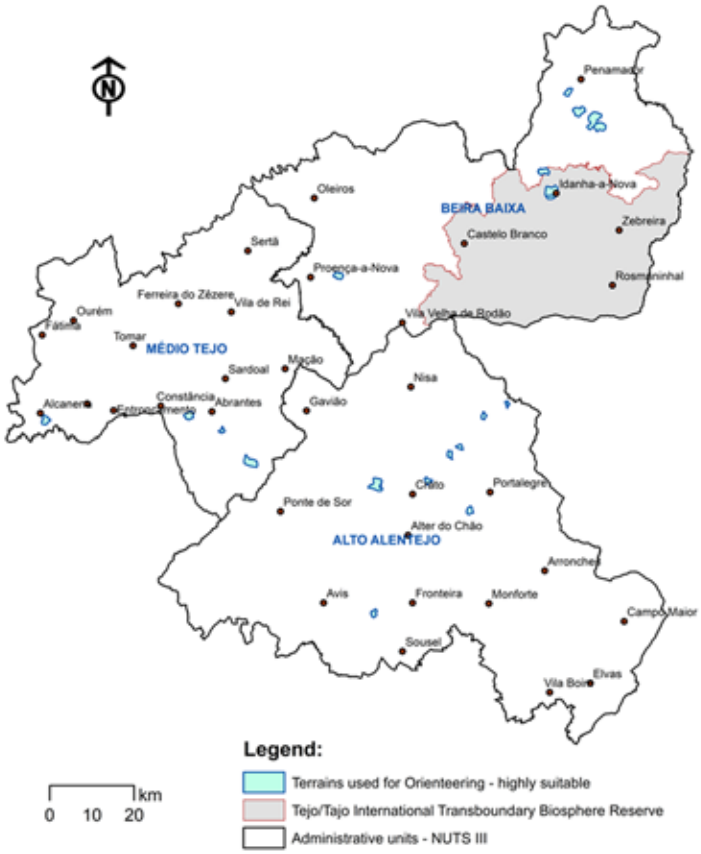


Table 3 shows the results of the pairwise comparison matrices, where the scores and weights of each criterion calculated using the AHP method are indicated. In the analysis performed, the value of the consistency ratio (RC) obtained was 0.03. Assuming, therefore, the existence of a good consistency in the pairwise comparison of the matrix.

Table 3. Weights and scores of the selected criteria

Criteria	Weight w_{ij}	Classes	Score
Land Use Land Cover	0.514	Forest, agroforestry	3
		Heterogeneous agricultural areas, scrub/herbaceous vegetation associations	2
		Arable land, pastures, discontinuous urban fabric	1
		Continuous urban fabric, water bodies, artificial infrastructures, and equipment	0
Slope	0.258	0 - 33.96%	3
		> 33.96%	0
Slope variation	0.122	< -7.44	0
		-7.44 - 22.75	3
		> 22.75	0
Topographic Position Index	0.053	< - 19.59	0
		-19.59 - 57.75	3
		> 57.75	0
Aspect variation	0.053	< -233.47	0
		-233.47 - 205.23	3
		> 205.23	0

As a result of the application of the Hierarchical Analytical Process, the mapping of suitability of terrain for Orienteering events was obtained (Figure 4). Based on the analysis of the results, 83465 ha, corresponding to 43.4% of the territory that have a high potential for the practice of Foot Orienteering.

Figure 4. Terrain suitability for foot orienteering

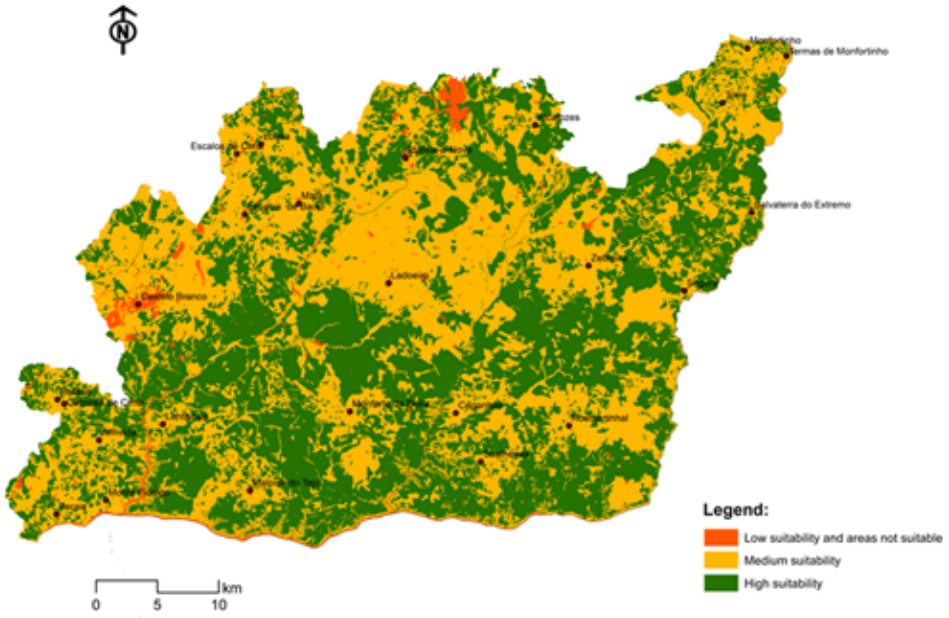
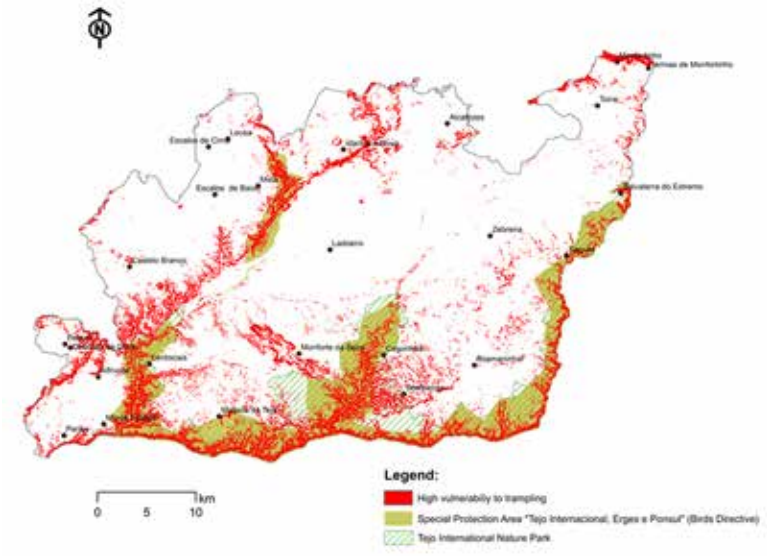


Figure 5 shows the areas with constraints to the practice of Orienteering, namely areas more vulnerable to trampling, and areas with vegetation and wildlife species more vulnerable and with high conservation status.

Figure 5. Constraints to the practice of orienteering

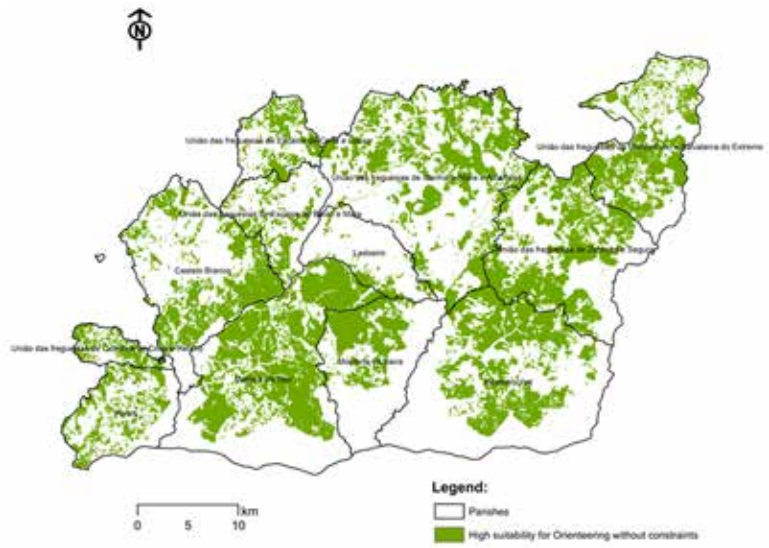


After areas with restrictions in terms of their use for carrying out orientation activities had been removed, the cartography of areas with high potential, which are represented in Figure 6, with an area of 57974 ha, corresponding to 34.3% of the territory that has a high potential for the practice of Foot Orienteering.

The parishes with a larger area with high suitability for foot Orienteering are Malpica do Tejo (11089 ha) the Union of parishes of Idanha-a-Nova and Alcafozes (9467 ha), Rosmaninhal (7987 ha) and the Union of parishes of Zebreira and Segura (7793 ha).

We highlight the potential of rural areas characterized by a diversity of uses and topographic features. These characteristics of the territory favourable to the practice of Orienteering in rural areas also enhance Orienteering in urban environments. This modality of Orienteering benefits from the rich cultural and social heritage of the region's urban areas.

Figure 6. Areas with high suitability for Orienteering



CONCLUSION

Based on the results obtained by the proposed methodology, we can conclude that the studied region has a high potential for practicing Foot Orienteering in about a third of the territory. This is a remarkable potential resource for the development of this sport.

The AHP proved to be adequate in assessing suitability for the practice of Orienteering events in the Portuguese part of the Tejo/Tajo International Transboundary Biosphere Reserve, as it allows for the integration of several criteria related to land cover as topography, a very useful interactive tool in the analysis of the territory. AHP is also an appropriate tool for considering the preferences of various stakeholders in the decision-making process, allowing a qualitative investigation of the nature, amount, and significance of resources.

In addition, the tourism benefits that result from a significant surface with the potential to develop this nature sports activity are combined with a cultural and built heritage offering that can also be explored in the context of holding events.

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 runability by the athletes, an important factor in determining suitability for Foot Orienteering. Other factors can influence the final choice of new land to map, namely the referencing of an area with prohibited or restricted access, access to the land by vehicles, distance from the traffic network, frequency of changes in use, and possible existing hazards.

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