DEFINING PRIORITY ZONES FOR CONSERVATION AND ECOTOURISM IN A PROTECTED AREA[1]

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ABSTRACT – With the objective of promoting nature conservation, this study proposes an environmental zoning for a protected area that contains part of the remaining Atlantic Forest, a global *hotspot* that is home to several endangered species of flora and fauna. Conflicting therewith, the protected area is an important tourist attraction in the region and receives many visitors throughout the year. For the zoning preparation, the main factors and constraints of each objective (ecotourism and conservation) are established, and a multi-criteria analysis is used, in addition to the MOLA (*Multi-Objective Land Allocation*) algorithm, to establish the most suitable areas for each use. Extreme protection areas are defined through the intersection of endemic vegetation and soils and altitudes above 1,500 m. Thus, a fraction of 18% is obtained for extreme protection, 59% for conservation, and 23% for areas destined for ecotourism development. The results demonstrate the advantages of using these methods, due to their simplicity, which can support administrators in planning the protected area. The zoning is in accordance with the International Union for Conservation of Nature (IUCN) recommendation because the conservation area corresponds to approximately 77% of the park area, reinforcing the suitability and applicability of the methodology that is used for the zoning of a protected area.

Keywords: GIS; Preservation area; Zoning.

DEFINIÇÃO DE ZONAS PRIORITÁRIAS PARA A CONSERVAÇÃO E ECOTURISMO EM UMA ÁREA PROTEGIDA

RESUMO – Neste trabalho foi proposto um zoneamento para uma área protegida, que tem como missão a conservação da natureza e contém parte da Mata Atlântica residual, um ***hotspot*** *mundial, que abriga diversas espécies da fauna e flora ameaçadas de extinção. Conflitando-se a esse uso, a área protegida é um importante atrativo turístico da região e recebe muitos visitantes ao longo do ano. Para a elaboração do zoneamento, foram estabelecidos os principais fatores e restrições de cada objetivo (ecoturismo e conservação) e utilizou-se de uma análise multicritério e do algoritmo MOLA (****Multi-Objective Land Allocation****) para estabelecer as áreas mais adequadas a cada uso. Foram estipuladas áreas de proteção extrema, através de uma interseção entre solos e vegetação endêmicas e altitudes superiores a 1500 m. Assim, obteve-se uma fração de 18% para as áreas destinadas a proteção extrema, 59% para a conservação e 23% para as destinadas ao desenvolvimento do ecoturismo. Os resultados explicitaram as vantagens da utilização desses métodos dada a sua simplicidade, podendo auxiliar os gestores no planejamento da área protegida. O zoneamento obtido está de acordo com a recomendação da IUCN, visto que a área de conservação correspondeu à aproximadamente 77% da área do parque, reforçando a adequabilidade e aplicabilidade da metodologia empregada para o objetivo de zoneamento de área protegidas.*

Palavras-chave: SIG; Área de preservação; Zoneamento.

1. INTRODUCTION

Sustainable tourism activities in protected areas are typically called ecotourism. However, reconciling environmental conservation with human activities at any level is a somewhat challenging task. Thus, an effective management strategy in these areas is essential so that ecotourism practices do not cause negative impacts on biodiversity conservation.

Conflicts between ecotourism practices and nature conservation can be particularly observed in protected areas, such as Conservation Units (CUs), where ecotourism activities are performed. One of the main goals of creating a CU is to maintain natural areas with as few changes as possible (CAREY et al., 2000). According to the *International Union for Conservation of Nature* (IUCN), a CU is "An area of land and/or sea especially dedicated to the protection of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (DUDLEY, 2008).

In this sense, as a spatial planning tool, zoning aims to spatially organise a CU into plots, called zones, which require different levels of protection and intervention, helping the CU meet its specific management objectives (IBAMA, 2002). The defined zones receive specific strategic management methods and land use standards according to their objectives. These uses typically consist of strict nature conservation actions for areas designated as protected and of controlled levels of human activities in other areas (BRASIL, 2000; GENELETTI; van DUREN, 2008; ZHANG et al., 2013).

Geographic Information System (GIS) technology contributes to the planning of a CU, classifying areas according to attributes of interest of use. The combination of the *Multi-Criteria Evaluation* (*MCE*) and *Multi-Objective Land Allocation* (*MOLA*) tools of the IDRISI *software* program allows the zoning of a CU based on a set of preferences, criteria, and indicators to be developed and provides the resolution of land use and occupation conflict issues through the visualisation and mapping of areas (MARINONI, 2004; HAJEHFOROOSHNIA et al., 2011). However, there is still a need for more detailed case studies that illustrate the steps and the use of such methods for performing effective zoning that can be applied in various contexts (ZHANG et al., 2013).

According to the Ministry of the Environment, Brazil has 1,940 federal, state, and municipal conservation units (BRASIL, 2015), and many of them still carry the responsibility of protecting two global hotspots: the Cerrado and the Atlantic Forest, with the latter ranking fifth in a list containing 25 global conservation priorities (BRANDON et al., 2005). The Atlantic Forest is most likely the most devastated and seriously threatened biome in the world, with only approximately 22% of its remaining original cover (LAGOS; MULLER, 2007; BRASIL, MMA, 2015). In addition, in this hotspot, the pace of change is among the fastest, and hence, the need for conservation action is more urgent (GALINDO-LEAL; CÂMARA, 2003).

The Serra do Brigadeiro State Park (Parque Estadual da Serra do Brigadeiro - PESB) is one of Brazil's most globally important CUs because it is the home of part of the residual Atlantic Forest and the biodiversity inherent to it. According to the State Forest Institute, the park is home to springs that contribute to two major watersheds, endemic vegetation and soil, and endangered species of flora and fauna (IEF, 2007). In existing floristic surveys of the PESB, 13 species that are part of the Red List of Endangered Plant Species of the state of Minas Gerais, Brazil (BIODIVERSITAS, 2000) and seven species in the Red Book of Brazilian Flora (MARTINELLI; MORAES, 2013) have been found. In the List of Endangered Brazilian Fauna Species registered in the Red Book, two bird species and four mammal species are found (MACHADO et al., 2008). Therefore, PESB is a very important CU among the "Priorities for Biodiversity Conservation in Minas Gerais, Brazil" (DRUMMOND et al., 2005).

From the ecotourism perspective, PESB boasts lush landscape scenery with the presence of waterfalls and peaks that attract numerous visitors. There are unmonitored, disordered, and clandestine visitation problems in some areas of the park (IEF, 2007). According to Moraes et al. (2010), Serra do Brigadeiro is threatened due to the rapid advancement of developmental models that suppress traditional cultures. Therefore, one should encourage the implementation of activities that take advantage of the PESB's potential in a more sustainable manner.

Law 9.985, of July 18, 2000, which institutes the National System of Conservation Units (Sistema Nacional de Unidades de Conservação - SNUC) in Brazil, establishes criteria for the creation, deployment, and management of CUs (BRASIL, 2000). However, the creation of a CU does not guarantee protection of the ecosystems that are part of it (DUDLEY et al., 1999). The lack of land tenure, the practice of illegal activities in and around the units, conflicts with local populations, and the lack of efficient and applicable management plans can be noted as problems that hinder the implementation and efficacy of a CU (TERBORGH et al., 2002; DOUROJEANNI, 2003).

Thus, it is of the utmost importance for the protected areas that they have a management and administration strategy to minimise these problems. In this sense, zoning, using GIS techniques, has been gaining momentum. However, the lack of zoning is common for protected areas in developing countries, and consequently, many protected areas are not effective in achieving the goals that were established in their creation (SABATINI et al., 2007). Hajehforooshnia et al. (2011) state that their study is one of the few that uses *MOLA* for zoning. In the scientific literature, one can find fewer publications on the zoning of land parks than on the zoning of marine parks.

Given the importance of preserving nature and the problematic situation of conflicts of land use and occupation in the PESB, this study aims to show the integration of the *MCE* and *MOLA* tools, in addition to their advantages, to define priority areas for extreme protection, conservation, and ecotourism development.

The relevance of the work is the methodology that is used with *MCE* and especially *MOLA*, which are tools that are still little explored in the context of zoning land for parks. These tools are used to generate the suitability maps, conflicting areas, and the final zoning, which may assist park managers in their decision-making.

2. MATERIAL AND METHODS

2.1. Study Area

The Serra do Brigadeiro State Park (PESB) is located in the state of Minas Gerais, Brazil, between the meridians 42º 40' and 40º 20' West and the parallels 20º 33' and 21º 00' South (Figure 1). PESB is managed by the State Forestry Institute of Minas Gerais (Instituto Estadual de Florestas de Minas Gerais - IEF/MG) and covers an area of 14,984 hectares with altitudes ranging between 1,400 and 1,985 metres. The climate is considered mesothermal, with mild to hot and humid summers; the average annual temperature is 18°C, reaching 0°C in the winter and 23°C during the hottest days; and the average rainfall is approximately 1,300 mm, with rains from November to March (IEF, 2007). The mountainous terrain is characterised by the presence of pontoons and ridges, alternated by altitude fields, rocky outcrops, endemic vegetation and soils, and native species of the Atlantic Forest. Serra do Brigadeiro is the home to several springs that contribute to forming major rivers of two river basins, in addition to protecting several endangered species of flora and fauna (IEF, 2007).

2.2. Data collection

The zoning of the PESB was performed in a GIS environment, with the ArcGIS 10.1 (ESRI, 2014) and IDRISI Selva 17.0 (EASTMAN, 2012). The broad database used includes the following: maps of soil types, vegetation, land use and occupation, roads, trails, peaks, sights, altimetry, hydrography, park boundaries, administrative headquarters, inns, employee residences, gates, and the communities around PESB.

Most of the database was obtained from the Centre of Studies and Forestry Development (Centro de Estudos e Desenvolvimento Florestal - CEDEF) in the city of Viçosa, Minas Gerais. Some ecotourist spots were extracted in the KML file format from the software *Google*

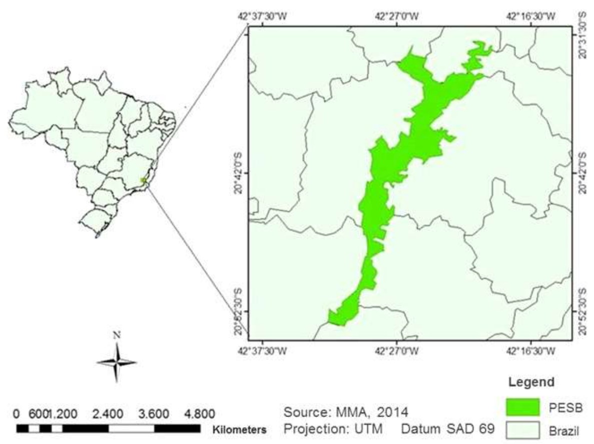

Figure 1 – Location of the Serra do Brigadeiro State Park (PESB), Brazil.
Figura 1 *– Localização do Parque Estadual da Serra do Brigadeiro (PESB), Brasil.*

Earth version 7.1.3.22.3 (2014) and converted into the *shapefile* format using ArcGIS 10.1. Other ecotourist spots were obtained through the geographic coordinates that are described in the PESB Management Plan, which is published by the IEF (2007). The hydrography and altimetry were extracted from an image in the GEOTIFF format, 1:250,000 scale, obtained from the website of the Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA) (MIRANDA, 2005). The springs were obtained from the hydrography with the "*feature vertices to points*" tool in ArcGIS 10.1.

Through the PESB altimetry, hydrography, and boundaries, the digital elevation model (DEM) was created. Spurious depressions were eliminated, generating a hydrographically conditioned model. Still in ArcGIS 10.1, with the "*Merge*" tool, the ecotourism attractions were grouped. The grouping related the attractions as follows: (a) Group 1 corresponds to the most visited places by ecotourists, such as waterfalls and inns; (b) Group 2 refers to the areas with a medium frequency of visitation, such as trails and peaks; and (c) Group 3 corresponds to the places that are mainly associated with the administrative sectors of PESB, with less frequent visitation.

After the data processing in ArcGIS 10.1, the data manipulation continued in IDRISI Selva for multi-criteria evaluation and land allocation.

2.3. Multi-Criteria Evaluation and Land Allocation

IDRISI Selva was used for multi-criteria evaluation and land allocation with the use of the *Multi-Criteria Evaluation* (*MCE*) and *Multi-Objective Land Allocation* (*MOLA*) tools.

The "*fuzzy*" function was used to standardise the factors in the range of 0 to 255 with linear rules, and the *Analytical Hierarchy Process* (*AHP*) was used to compare the factors pairwise and then attribute weights to each. For each objective – ecotourism and conservation – a *Weighted Linear Combination* (*WLC*) scenario was created. As a result, a suitability map was obtained for conservation and another map for ecotourism.

These maps were then ordered in terms of suitability through the "*Rank*" algorithm; subsequently, with the "*CrossTab*" tool, the scenarios were crossed and compared, and the conflicting areas were identified.

Finally, the *MOLA* algorithm was used to resolve conflicts in areas that are destined for both objectives, conservation and ecotourism, prioritising the objective cell with the highest weight. To process this algorithm, the images that were obtained in "*Rank*", the weights, and the required area of each objective were inserted. Due to the importance of biodiversity conservation of the PESB, the highest weight was attributed to the conservation objective (0.7) compared to ecotourism (0.3). The required area for conservation was calculated according to the IUCN, which recommends that at least 75% of land or water within a protected area be managed to protect natural ecosystems, species, and their associated habitats (DUDLEY, 2008). Thus, the areas that were defined for ecotourism and conservation were 3,746.10 and 11,238.20 hectares, respectively.

Despite the importance of mapping the potential habitats of the endangered species in the park, it was not possible to obtain such information and/or mapping. To develop these, the participation of a team that specialises in surveying wildlife, flora, and habitats would be required, including field sampling and subsequent data processing. However, due to the imposition of land relief and areas with endemic vegetation or soils, to prioritise conservation areas with little or no human interference, the extreme protection zone was created.

The extreme protection zone resulted from the intersection of endemic soil and vegetation maps, combined with an altitude above 1,500 metres. The PESB areas that are above 1,500 metres in altitude are characterised by a high-mountain environment with rich endemic vegetation and soils and are virtually untouched and isolated (IEF, 2007). This zone was spatially superimposed onto the map that was obtained after the *MOLA*, finally resulting in the three management zones: the extreme protection zone, the conservation zone, and the ecotourism zone.

2.4. Definition of the criteria

The identification of the use criteria of natural areas is a technical activity based on theory, empirical research, or common sense (HAJEHFOROOSHNIA et al., 2011). Moreover, decision-making with regard to ecotourism in protected areas is a challenging task because it involves people from several fields, in addition to the protected area administrators (EAGLES, 2002). The criteria for conservation and ecotourism (Tables 1 and 2) were previously defined and evaluated, and they were worked into a single hierarchical *MCE* for each objective. Based on the analysis of these criteria, the constraints and factors were established.

To establish the constraints and control points of the "*fuzzy*" function for each factor, the following were taken as the basis: Law 12.651/2012 – Brazilian Forest Code (BRASIL, 2012), the Methodological Planning Roadmap of the Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA) (2002), and the Management Plan of the PESB (IEF, 2007), in addition to considerations found in the literature (BONFIM et al., 2003; FUNG; WONG, 2007; SOUZA; MARTOS, 2008; COHEN; SILVA, 2010; ZHANG et al., 2013).

3. RESULTS

The suitability of the conservation and ecotourism maps (Figures 2a, 2b) were based on the established criteria. In general, the best suitability results for conservation were found at the peaks of the high altitudes of the park, where rock pontoons and endemic species are predominant. The distance from springs, hydrography, and endemic plant species were the most important criteria for developing the park's conservation suitability map (Table 3). A comparison matrix was prepared for the consideration of the factors.

The suitability map for ecotourism had the best results in the central areas of the park, through which the paved road goes, and near the head office and inns. The most important criterion for the ecotourism suitability map was the proximity to points in Group 1 because in this group are the most recognised and

Table 1 – Defined criteria for the conservation objectives.
Tabela 1 – *Critérios definidos para o objetivo conservação.*

Criteria	Description
Distance from springs	Springs are valuable sources of water. Their surroundings must be preserved to avoid contamination. In addition, the areas within 50 m of springs are permanent preservation areas established in the Brazilian Forest Code (BRASIL, 2012).
Distance from Hydrography	The areas near rivers must be protected to prevent silting. The Brazilian Forest Code requires that rivers have a permanent preservation range in their surroundings (BRASIL, 2012). In addition, Zhang et al. (2013) found many endangered species along the streams and rivers in a protected area.
Vegetation	The PESB is home to part of the Atlantic Forest. Some species in the area are considered endemic and are found in restricted areas, and therefore, they should be protected (IEF, 2007).
Soil	Similar to vegetation, some soils are considered endemic (IEF, 2007). In addition, these soils are extremely vulnerable to trampling.
Declivity	Law 12.651/2012 establishes that areas with sloping greater than 45º must be protected (BRASIL, 2012).
Altitude	Locations with higher altitudes have flora and fauna that are little modified by human action due to the difficulty of access (IBAMA, 2002)
Paved Roads	According to Zhang et al. (2013), paved roads cause direct and indirect impacts on the ecosystem and the landscape. Direct impacts involve the loss of habitat and forest area. Indirect impacts are the fragmentation and degradation of the ecosystems and the landscape.
Non-paved Roads	The effects of non-paved roads are similar to the impacts of paved roads but on a smaller scale. The proximity to roads affect the park's fauna due to excessive noise and vehicle exhaust emissions (COHEN; SILVA, 2010).
Anthropic Areas	Conservation targets that are near anthropic areas have a higher risk of disturbance; thus, the distance from these areas increases the level of biodiversity protection. Hunting and the illegal collection of flora and fauna are risks that visitors bring when visiting a protected area (COHEN; SILVA, 2010).
Communities	The surrounding communities can bring negative impacts to conservation because they may use the park's resources in an unsustainable and illegal manner. In addition, the use of fire that is applied by residents with agropastoral purposes around the PESB threatens the biodiversity near the park's boundaries (BONFIM et al., 2003).

Table 2 – Defined criteria for ecotourism objectives.
Tabela 2 – *Critérios definidos para o objetivo ecoturismo.*

Criteria	Description
Group 1	Group 1 includes the most important and visited sights of the PESB, which deserve to be appreciated by ecotourists.
Paved Roads	The displacement to the PESB is an important criterion. Areas that are closer to paved roads receive a higher number of ecotourists due to the easy access.
Non-paved roads	Due to the large extension of the park, non-paved roads are essential for the displacement of ecotourists.
Group 2	Group 2, despite having lower visitation, has landscaped sights that attract ecotourists; these include trails, which are not only attractions but also means of transportation between sights. According to Souza and Martos (2008), trails provide a visitor's direct contact with the different attractions and environments that are provided by the diverse physiognomies and landscapes.
Altitude	The altitude suitability for ecotourism was considered to be increasing to some extent (because the most beautiful sights are at the highest altitudes). An altitude range was considered great for ecotourism, and after a certain point, it decreased because, according to Cohen and Silva (2010), sights that are located at hilltops and with difficult access by foot typically receive few visitors.
Anthropic Areas	Anthropic areas are important for ecotourism because restaurants and inns are located in them. It is important to note that in addition to several environmental impacts, the economic and social aspects of ecotourism activities must be considered in the established criteria (FUNG; WONG, 2007).
Group 3	Group 3 corresponds to the administrative areas of the PESB.

visited tourist attractions where most of the park's visitors go. The proximity to paved and non-paved roads was considered a factor as important as the sights because the accessibility to the sites is closely related to the visitation frequency (Table 3).

Although the criteria used for ecotourism and conservation are different, some areas showed suitability for both objectives. These areas, called conflict regions, were identified by running the "*CrossTab*" command, and they corresponded to 16.5% of the park's area (Figure 2c). Thus, through the *MOLA* algorithm, each pixel was allocated to one of the objectives; then, the zone that was defined for extreme protection was overlaid onto this map. The result was the final zoning of the park, with 23% of the areas being destined for ecotourism, 59% for conservation, and 18% for extreme protection (Figure 2d).

4. DISCUSSION

The Atlantic Forest is the second largest rainforest in the Americas; it originally stretched along the Brazilian coast, and in the past, it covered over 1.5 million km^2, with 92% of it belonging to Brazil (FUNDAÇÃO SOS MATA ATLÂNTICA and INPE, 2002; GALINDO-LEAL; CÂMARA, 2003). Currently, only approximately 7% of the Atlantic Forest remains well conserved in segments of more than 100 hectares. Although reduced and very fragmented, it is estimated that there are approximately 20,000 plant species in the Atlantic Forest (approximately 35% of the existing species in Brazil), including several endemic and endangered species. This wealth is greater than in some other continents (17,000 species in North America and 12,500 in Europe), and for this reason, the Atlantic Forest is a priority for the conservation of global biodiversity (BRASIL, MMA, 2015). The PESB, with an area that is larger than 14,000 hectares, is home to a large extension of the remaining Atlantic Forest in Minas Gerais (IEF, 2007), and therefore, it is important to invest in actions that promote its conservation.

It is noteworthy that conservation is expected for the PESB area in its entirety, though not all areas have this designation in their names. According to Binot et al. (2009), most natural resource management programmes aim to integrate issues of conservation and development, involving the stakeholders in the management of protected areas. Thus, the purpose of the proposed zoning was to prioritise some areas that need further efforts for biodiversity conservation and to sustainably manage the greater suitability areas for the development of ecotourism within the boundaries of the PESB.

The areas that are destined for conservation are mainly in the higher altitude regions of the PESB. When

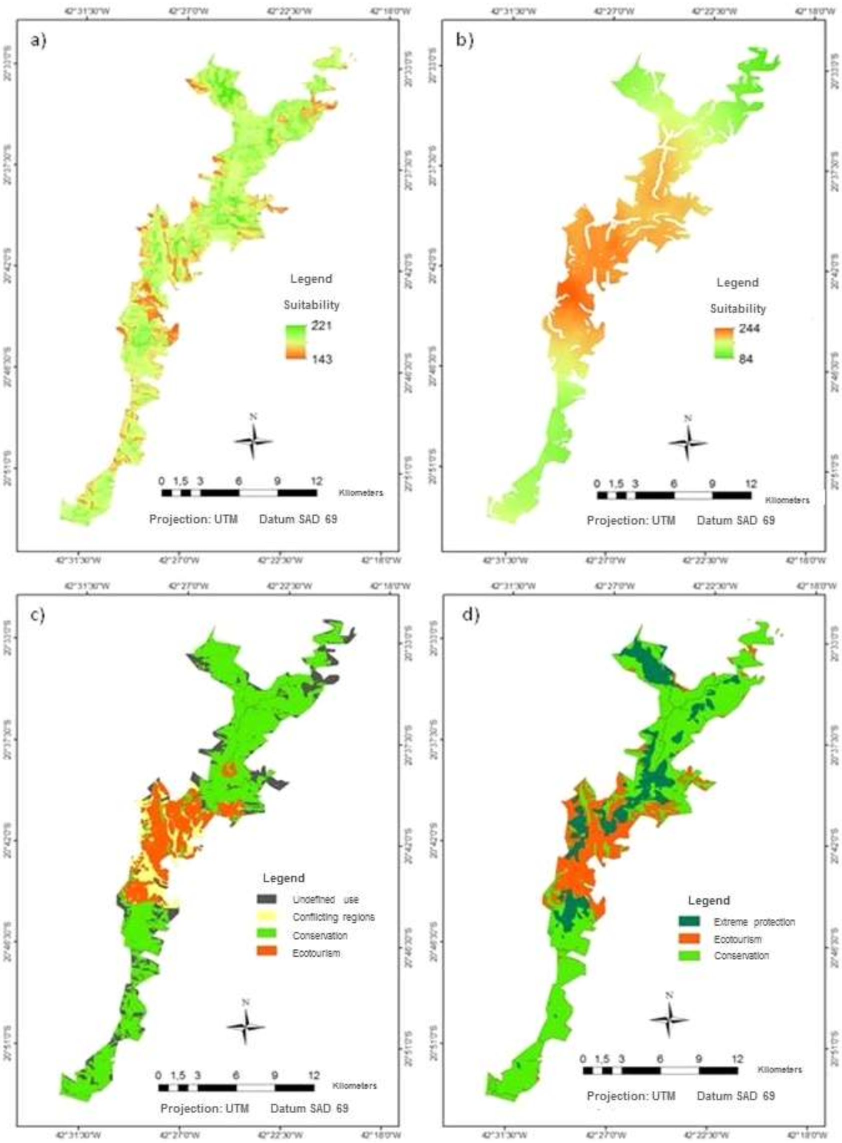

Figure 2 – a) *WLC* scenario for conservation, b) *WLC* scenario for ecotourism, c) Conflicting regions, d) Zoning.
Figura 2 *– a) cenário WLC para conservação, b) cenário WLC para ecoturismo, c) regiões de conflito, d) zoneamento.*

adding the extreme protection areas to the conservation areas, the result is approximately 11,481 hectares, corresponding to 77% of the total area of the park. As expected, this result is in line with the recommendation by the IUCN (75% rule).

Using a multi-criteria analysis, Zhang et al. (2013) develop a zoning study for a park in China, dividing it into five zones, where those destined for greater conservation (zones 1 and 2) amount to 71% of the park's total area. Hajehforoosshnia et al. (2011) conduct a zoning study for a protected area in Iran, using multi-criteria analysis and *MOLA*, and the area destined for conservation only is approximately 70% of the park. Geneletti and Van Duren (2008) use multi-criteria analysis and *MOLA* in a protected area in Italy and define three zones, with the sum of the stable areas covering 70% of the protected area. These authors consider the respective zoning results to be acceptable.

Table 3 – Criteria weights based on the pairwise comparison matrix: a) Conservation, b) Ecotourism.
Tabela 3 – *Pesos dos critérios a partir da matriz de comparação par a par: a) Conservação, b) Ecoturismo.*

a) Criteria	Weights
Springs	0.2041
Hydrography	0.2041
Vegetation	0.2041
Soils	0.0890
Declivity	0.0890
Digital elevation model	0.0890
Paved roads	0.0402
Non-paved roads	0.0402
Anthropic areas	0.0202
Communities	0.0202
b) Criteria	**Weights**
Group 1	0.2297
Paved roads	0.2297
Non-paved roads	0.2297
Group 2	0.0961
Altitude	0.0396
Anthropic areas	0.0396
Group 3	0.0396

The areas that are destined for ecotourism in the park correspond to 22% of the total area. This percentage is close to the result of 29.02% of the area found by Bunruamkaew and Murayama (2011) that is classified as moderately suitable for ecotourism in a protected area in Thailand, where passive activities with minimal impact on the environment are allowed. These authors also use the *MCE* method and demonstrate the ability to apply these methods to other protected areas. In general, the ecotourism zones in the PESB are established in the centre and near the boundaries of the PESB, as shown in Figure 2d. In addition, it is observed that the paved road that crosses the PESB has a major impact on the determination of the ecotourism areas because most of these areas are established next to it.

Many authors have reported the advantages of using GIS in environmental zoning (BOTEVA et al., 2004; GENELETTI; van DUREN, 2008; HAJEHFOROOSHNIA et al., 2011; PILEHFOROOSHHA et al., 2014). The automatic generation of each step of the process precludes subjectivity in the interpretation of the results because the development of zoning for a protected area demands that complex decisions be made. Furthermore, the factors and criteria may be modified and reformulated at any time, allowing for updates, greater freedom of repetition, and the verification of the analyses.

The identification of the conflict regions (Figure 2c) during the preparation of the zoning is important for a preliminary diagnostic of the areas that require further research and data, in addition to assisting park administrators in allocating a greater commitment to them. According to Los Monteros (2002), the success of sustainable ecotourism in protected areas is only achieved if management programmes and strategies are well employed.

Difficulties are found in the PESB region in obtaining georeferenced data and information. Although it is a great challenge to map endangered species due to population dynamics and habitats, in this study, more consistent results would have been obtained if this mapping were available for the PESB.

Given the conformity of the conservation and ecotourism zoning results with the literature, this zoning is considered adequate for the proposed objective, easy to execute, and possible to replicate in other areas with conflicting uses. However, it is recommended that the results that were obtained with GIS be enhanced with the opinions of experts, researchers, managers, and other stakeholders.

5. CONCLUSION

This study illustrates the integration of *MCE* tools and the *MOLA* algorithm in the preparation of a zoning study of a protected area. The advantage that is demonstrated in this model is the feasibility of its implementation by managers in the planning of protected areas, due to its simplicity, and the fact that it can help them in applying precautionary measures and remediation for conflicting areas according to the park's objectives.

The obtained zoning is in accordance with the IUCN recommendation because the conservation area corresponds to approximately 77% of the park's area, reinforcing the suitability and applicability of the methodology that was used to zone the protected areas. However, we cannot guarantee that all of the target species and fragile ecosystems are under protection. Thus, enhancing this model is recommended to ensure that all of the CU's objectives are met, and therefore, the inclusion of habitat data is considered important for future models.

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