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Antalya Turkey

Understanding Mediterranean Landscapes Human vs Nature

Proceedings

Editors: Hakan Alphan, Meryem Atik, Emel Baylan and Nilgül Karadeniz

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Understanding Mediterranean Landscapes:
Human vs. Nature

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Landscape Research Society (PAD)

Landscape Research Society is a national non-governmental organization which was established in 2012 in Ankara, Turkey. The goals and objectives of the society;

- To approach natural and cultural components together pursuant to landscape scale; to emphasize flows and functions existing in the landscape and to preserve this structure with human and all the other living and non-living things in landscape; to contribute to transfer these components to next generations and to mold public opinion about these issues;

- To assess every human activity affecting natural and cultural landscapes from a social and ecological benefit point of view and to reconstruct these activities within this regard;

- To redefine human needs within place perception, to approach production/consumption patterns pursuant to resource management and to enhance and spread technologies, architecture, life styles that fits that management best.

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- Natural landscape
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- Landscape ecology
- Landscape quality
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Foreword

International Congress on Landscape Ecology Understanding Mediterranean Landscapes; Human vs. Nature was held between 23 and 25 October 2014 in Antalya, Turkey. The Congress was hosted and organized by Landscape Research Society (PAD). Main supporters were IALE International, IALE Europe, Society for Conservation Biology and Ministry of Forestry and Water Affairs the Directorate of Nature Conservation and National Parks. The Congress brought together 85 participants from 17 countries.

This event was the first international meeting that particularly focuses on landscape ecology in Turkey. The main goal of the event was to exchange knowledge and information to create cooperation between related institutions and experts from different disciplines concentrated on Mediterranean landscapes and dealing with various aspects of landscape ecology.

For their assistance with the compilation of this Proceedings I extend my sincere appreciation to the organising committee members and also editors: Hakan Alphan, Meryem Atik, Emel Baylan and Nilgül Karadeniz. I present my deepest gratitude to the former president of IALE Felix Kienast, for supporting us. I thank to Almo Farina, Teresa Pinto Corriera and Linda Olswig Whittaker for coming and gracing our event with their keynotes; The Ministry of Forestry and Water Affairs Nature Conservation and National Parks Department especially Nihan Yenilmez Arpa for becoming a part of our society; scientific committee members for their invaluable comments, Interaktif Is Web Solutions company and Doruk Karaboncuk for solving every technical problem for us; Akdeniz University Faculty of Agriculture Department of Landscape Architecture and Veli Ortaçeşme for his local support; Congress volunteers for their efforts during the congress and preparation of this Proceedings: Gülin Özdemir, Büşra Tanrıkulu, Ali Bakır, Buket Şenoğlu, Deniz Akman, Esat Furkan Engin, Esra Akgül, Filiz Ubay, Meltem Demiryürek, Merve Tekin, Veysel Dağ and lastly to the distinguished guests and participants for contributing their valuable time to attend this event.

President
Semiha DEMİRBAŞ ÇAĞLAYAN

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Agroforestal Suitability Evaluation of a Subregional Area in Portugal Using Multicriteria Spatial Analysis

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Abstract

It is generally agreed that the choice of the most suitable uses based in soil and climatic factors, complemented with socio-economic criteria, promotes sustainable use of rural land. There are, however, different methodologies for defining the soil suitability to agroforestal systems or natural and seminatural ecosystems, including agricultural uses, forest plantations, agro-forestry areas and priority areas for nature conservation. Many of these methods rely on decision support systems based on multicriteria spatial analysis. In this study we intended to determine the different levels of suitability for agro-forestry use in a subregion located in the center of Portugal, near the border with Spain. To the effect we used a set of soil and topographic variables. The legal constraints and land cover were also included. The suitability evaluation was performed using the Analytic Hierarchy Process (AHP). A spatial analysis was also performed in order to confront the land use matrix with the soil potentiality. This analysis allows to identify areas where the use and management it is in accordance with their suitability, as well as areas where the use must be subject to a conversion or at least to a change of management mode.

Key Words: Land use suitability, Analytic Hierarchy Process, Geographic Information Systems, Multicriteria analysis

INTRODUCTION

Agroforestal management aims to choose the land uses according to soil suitability, contributing to an integrated and economically sustainable use of the land. The unprecedented expansion of human need for resources requires an approach to decisions regarding land use that would ensure the maintenance of biodiversity and sustainable natural resource utilization for the continued delivery of ecosystem services.

According to FAO (1976) suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use. The process of land suitability classification is the evaluation and grouping of specific areas of land in terms of their suitability for a defined use.

Site suitability assessment is inherently a multicriteria problem. That is, land suitability analysis is an evaluation/decision problem involving several factors. In general, a generic model of site/land suitability can be described as:

$$S = f(x_1, x_2, \ldots x_n) \quad (1)$$

Where S = suitability measure; x_1., x_2, …, x_n = are the factors affecting the suitability of the site/land.

Multicriteria decision analysis (MCDA) deals essentially with complex decisions that involve a large amount of information, a number of alternative outcomes and criteria to assess these outcomes. MCDA techniques can be used to identify a single preferred option, to rank options, to short-list a number of options for further investigation, or simply to distinguish acceptable from unacceptable alternatives (Malczewski 2004, Roy 1996, Collins et al. 2001). Thus, multicriteria evaluation is used to solve spatial decision problems derived from multiple criteria. By integrating the evaluation techniques with GIS, the influential factor are evaluated and more accurate decision were taken (Parimala & Lopez 2012).

The Analytic Hierarchy Process - AHP (Saaty 1980) is a multi-criteria tool considered to be relevant to nearly any ecosystem management application that requires the evaluation of multiple participants or complex decision-making processes are involved (Schmoldt & Peterson 1997, Schmoldt et al. 2001, Reynolds & Hessburg 2005).

This work was intended to search for the suitable areas which can be exploited for agroforestal land uses in the subregion of Beira Interior Sul. In this research, site suitability analysis was carried out using GIS and the AHP as multicriteria decision analysis (MCDA) technique.

A spatial analysis was also performed in order to confront the land use with the soil potentiality. This analysis allows to identify areas where the use and management it is in accordance with their suitability, as well as areas where the use must be subject to a conversion or at least to a change of management mode.

MATERIAL AND METHODS

The subregion of Beira Interior Sul (NUT III) includes four municipalities: Idanha-a-Nova, Penamacor, Vila Velha de Ródão and Castelo Branco (**Figure 1**).

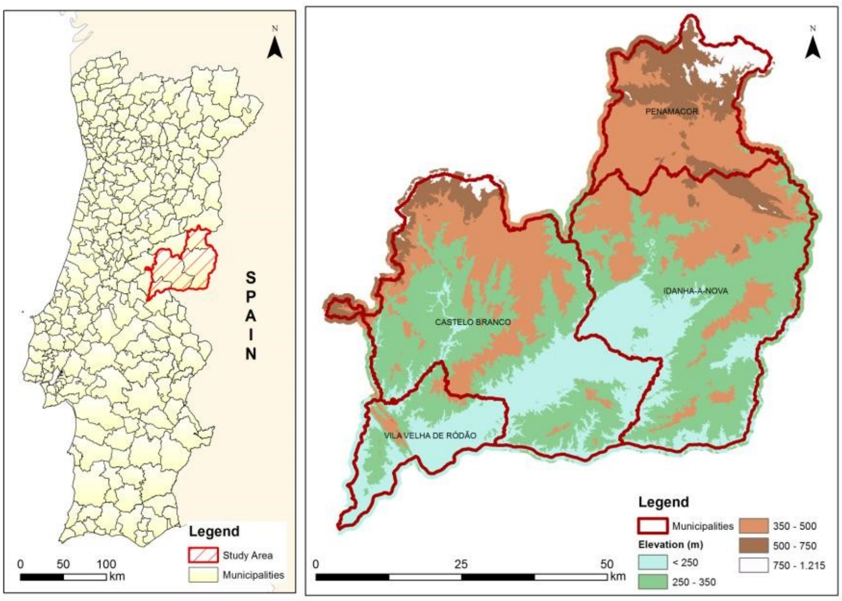


Figure 1: Study area location.

As **Figure 2** shows that the majority of the territory is occupied by forest and agroforestry uses (60.8 %) and agriculture (36.2 %).

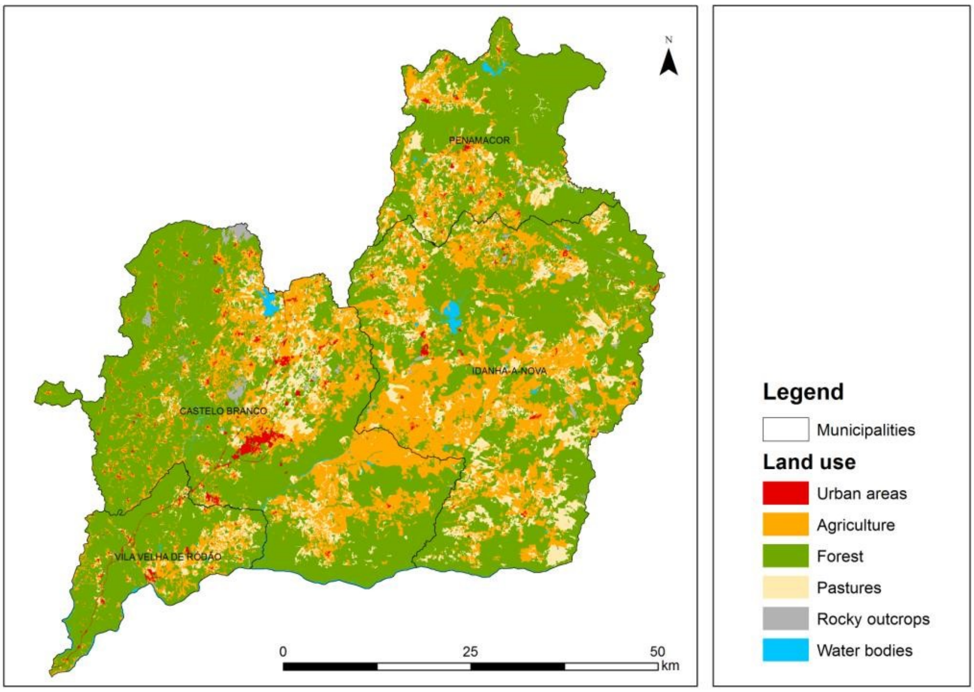
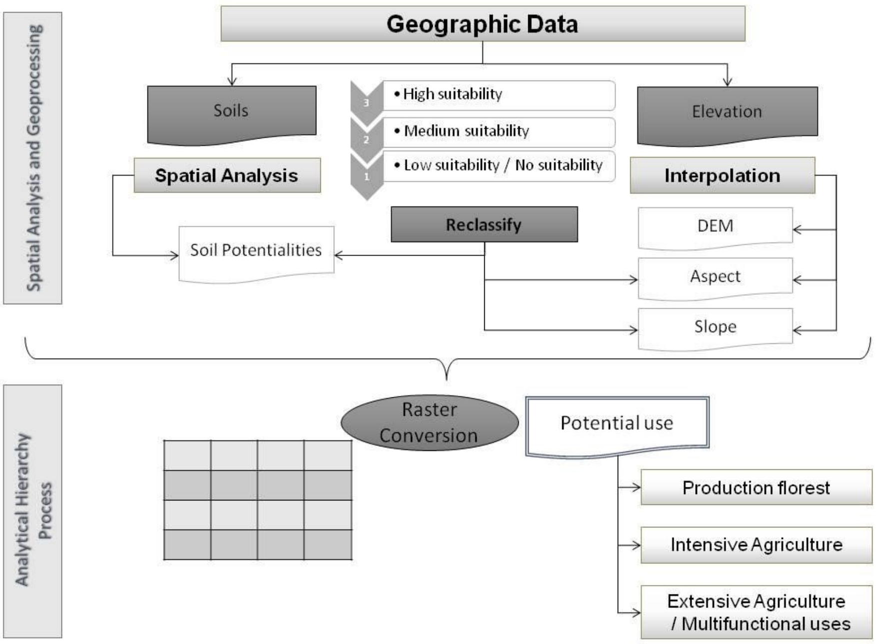


Figure 2: Land use map (2007)

Figure 3 presents the methodology used to determine suitability for agroforestal land uses, namely production forest, intensive agriculture and extensive agriculture/ multifunctional uses (agroforestry).



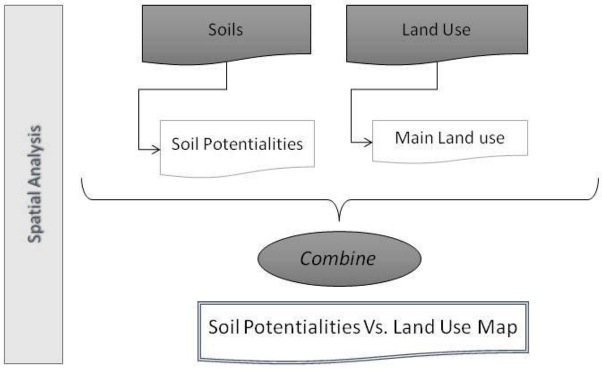


Figure 3: Methodology work flow.

The classification of agroforestal suitability resulted from the integration of a set of biophysical criteria using ArcGIS 10.2 software, based on the climate and soil requirements of crops and forest stands and the optimal operating conditions associated with different uses. Geoprocessing and spatial analysis was performed to geographic data, namely soils, elevation in order to produce the following layers: soil potentiality, slope and aspect

To define the soil potential for different crops and forest stands the soil theme attribute table was edited. Soils were reclassified in potentiality classes shown in **Table 1**.

Table 1: Soil potentialities (UNESUL 1996)

Potentiality class	Soil characteristics	Potential use
I	Different soil types that present high to very high constraints to production uses due to soil thickness, vulnerability to erosion or stoniness. With very low fertility.	Woodland and scrub with soil protection and recovery functions. In some cases, more favorable, pasture under a "montado" system.
II	Soils with coarse texture, without severe erosion problems, generally with low to very low fertility.	Forestry (pineyards and "montado" system), pastures, vineyards. In some cases cereal crops and horticulture if water and organic matter is available.
III	Soils without severe erosion problems. With medium to low fertility.	Cereal crops, horticulture, orchards and improved pastures. Forestry.
IV	Soils without erosion problems. With medium to high fertility.	Cereal crops in intensive mode, orchards, improved pastures and forestry. Soils suitable for olive groves.
V	Soil with high fertility.	Good for different uses depending from drainage, soil texture and availability of irrigation water: irrigations systems. Intensive forestry.
Rocky outcrops	-	Not suitable
Social areas	Urban areas and water bodies	Not suitable

The reclassification of soils in its potentiality is based in their physical and chemical proprieties, namely: texture, structure, field capacity, mineral reserves, organic matter, types of clay, cation exchange capacity, degree of saturation, pH, etc. The factors of soil formation (pedogenesis) have also importance to evaluate soil fertility (UNESUL, 1996).

A digital elevation model (DEM) was generated from contour maps with a pixel size of 100 m. Then we created layers of aspect and slope classes from de DEM. Those layers were reclassified based in their importance as constraints to agroforestal uses. Slope is a limiting factor to land use, affecting, for example, the machinery access and susceptibility to soil erosion. Aspect determines the amount of incident solar radiation, influencing the microclimate.

The different layers were classified in three suitability levels: low or no suitability (1), medium suitability (2) and high suitability (3). After creating layers resulting from the reclassification in suitability levels, the general suitability for each land use was performed using a multicriteria decision analysis - the Analytic Hierarchy Process - AHP (Saaty, 1980).

AHP is based on three main principles which are decomposition, comparative judgment and synthesis of priorities. Pairwise comparison is the basic measurement used in the AHP procedure. The synthesis principles takes of the derived ratio scale local priorities in the various level of the hierarchy and constructs a composite set of alternatives for the elements at the lowest level of the hierarchy (Malczewski 2004). The fundamental concept of AHP lies in proceeding from a pairwise comparison of criteria to evaluate the weights that assign relative importance to these criteria. This method is a very popular in calculating weighting factor.

Pairwise comparison is performed based on the rating scale proposed by Saaty (1980) shown in **Table 2**. Two factors are compared using the rating scale which ranges from 1 to 9 with respect to their relative importance. This parameter is computed against each pair based on the opinion of experts. The relative importance between each criteria is shown in **Table 3**.

Table 2: Pairwise Rating Scale.

Intensity of Importance	1	3	5	7	9	2, 4, 6, 8
Description	Equal importance of both elements	Weak importance of one element over another	Essential or strong importance of one element over another	Demonstrated importance of one element over another	Absolute importance of one elements over another	Intermediate values between two adjacent judgements

Table 3: Pairwise Comparison Matrix

Criteria	Soil suitability	Slope	Aspect
Soil suitability	1	9	7
Slope	1/9	1	5
Aspect	1/7	1/5	1

ArcGIS software was used to process the input where the priority of each factor is calculated using the eigenvectors. The weights calculated using AHP are shown in **Table 4**.

Table 4: Criteria weights

Criteria	Eigenvalues	Eigenvector of largest Eigenvalue	Weights
Soil suitability	3,3974	0,9766	77,91%
Slope	-0,1987	0,2018	16,10%
Aspect	-0,1987	0,075	5,99%

[Consistency ratio CR= 0.3821]

As a conclusion from the literature reviews and discussion with experts in agrarian sciences, a criterion factor for suitable areas for forest and agriculture as shown in **Table 5**.

Table 5: Criterion Factor and Ranking

Criteria	Classes	Suitability		
		Production forest	Intensive agriculture	Extensive agriculture/ Multifunctional use
Soil suitability	Class I	1	1	2
	Class II	3	2	3
	Class III	3	2	3
	Class IV	2	3	2
	Class V	2	3	2
	Social areas	1	1	1
	Rocky outcrops	1	1	1
Slope	0 - 3%	3	3	3
	3% - 8%	3	3	3
	8% - 16%	2	2	3
	16% - 30%	2	2	2
	> 30%	1	1	1
Aspect	Flat	3	2	2
	South/West	3	2	2
	East	3	3	3
	North	3	2	2

3 - high suitability; 2 - medium suitability; 1 - low suitability / no suitability

In the end, a spatial analysis was performed in order to confront the land use with the soil potentiality. For that purpose the ArcGIS command *combine* was used. This command generate combinations of values from two layers. From the analysis of the resulted layer the degree of compliance between land uses and land suitability.

RESULTS, DISCUSSION AND CONCLUSION

In order to obtain the slope and aspect maps (**Figure 4 and 5**) from DEM a surface analysis was performed.

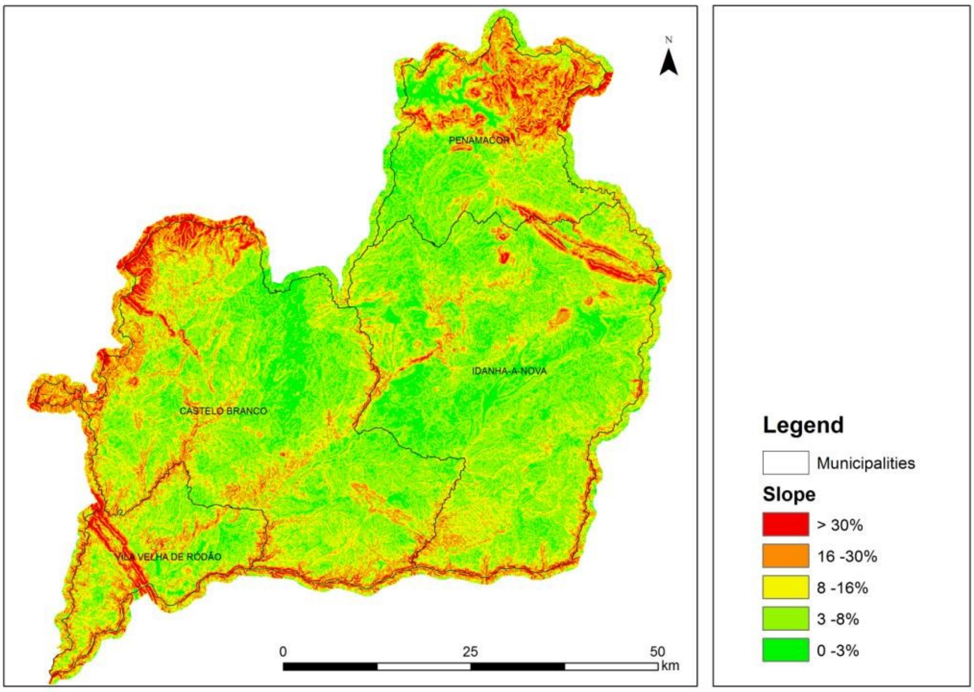


Figure 4: Slope map

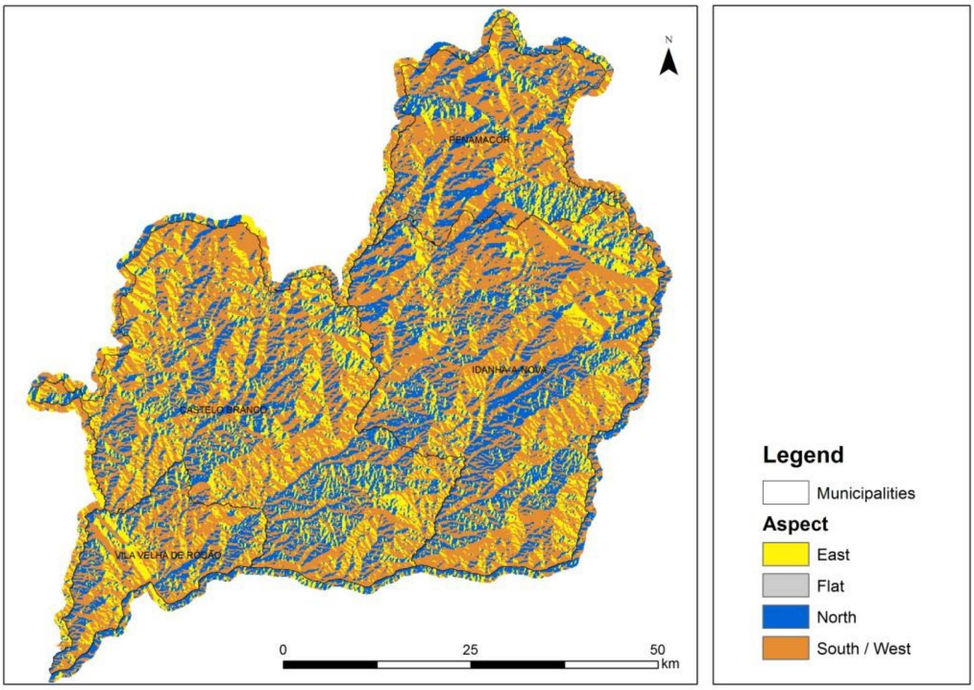


Figure 5: Aspect map

From the reclassification of soil layer we obtain a map representing its potentialities (**Figure 6**). This map allows to identify the forest and agricultural uses more suitable to the different soils, and areas not suitable for production.

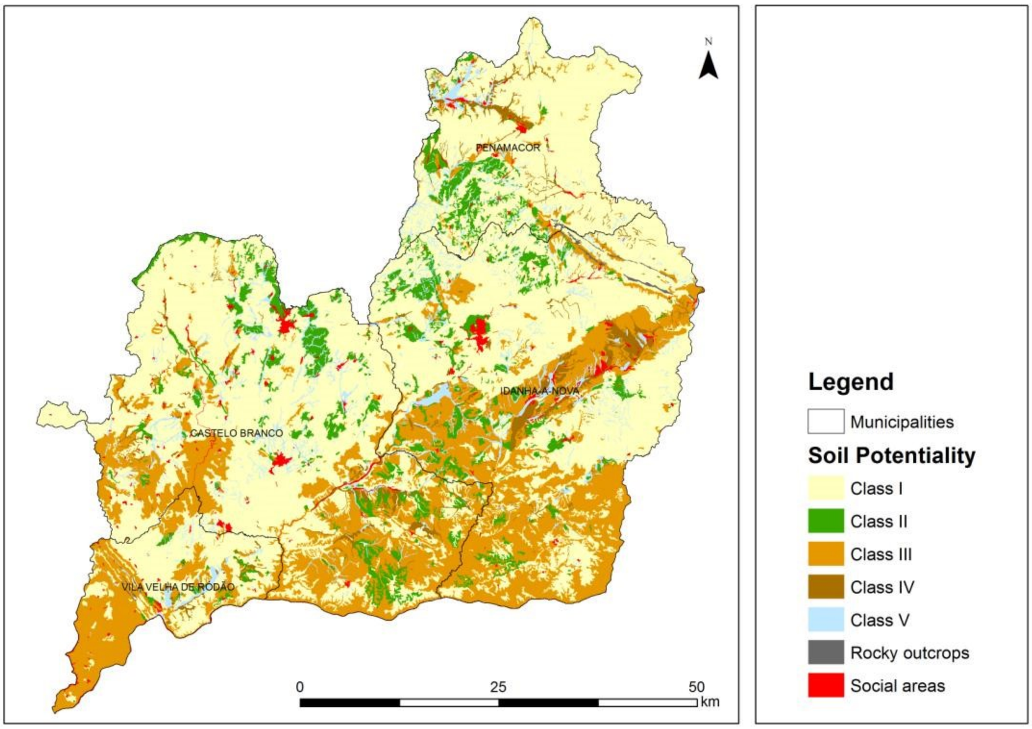


Figure 6: Soil Potentiality

In the following maps we present the results of Analytical Hierarchy Process (**Figure 7, 8** and **9**).

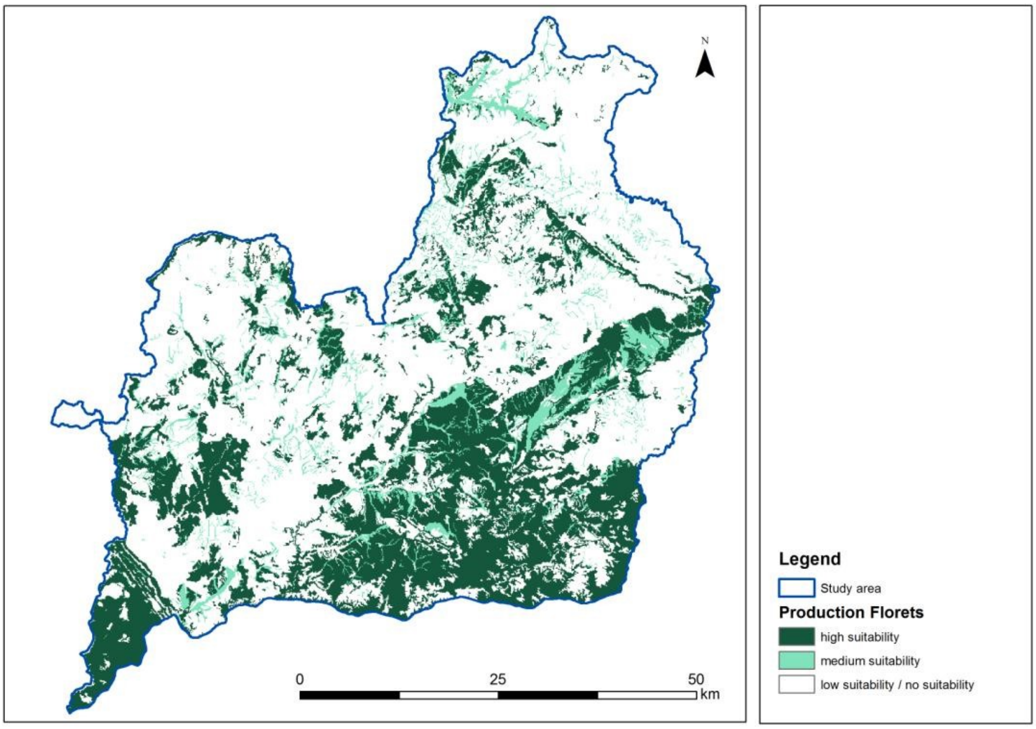


Figure 7: Suitability for production forest.

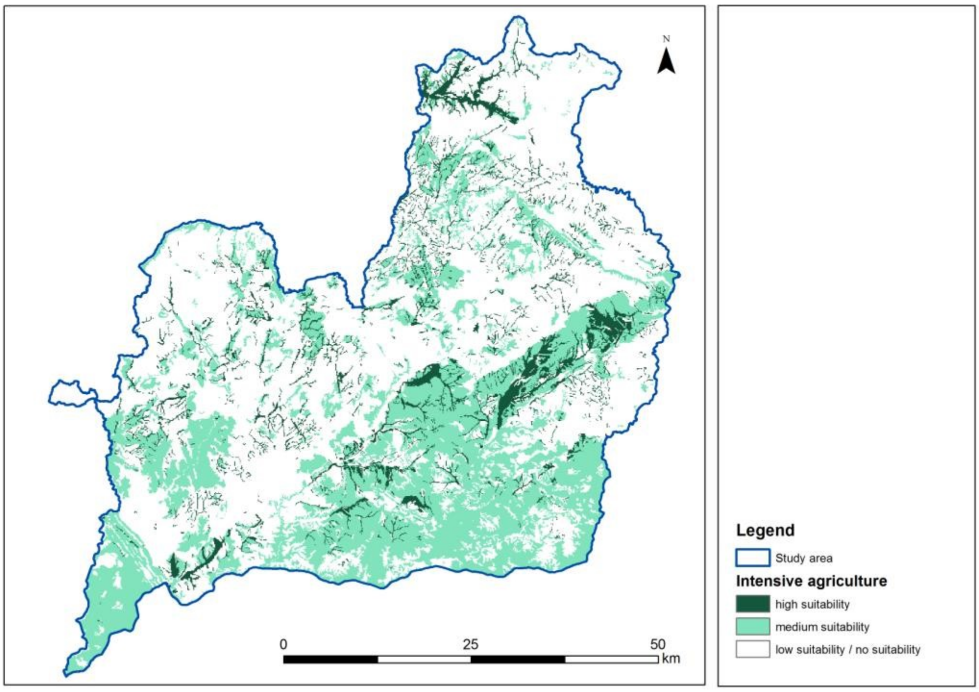


Figure 8: Suitability for intensive agriculture.

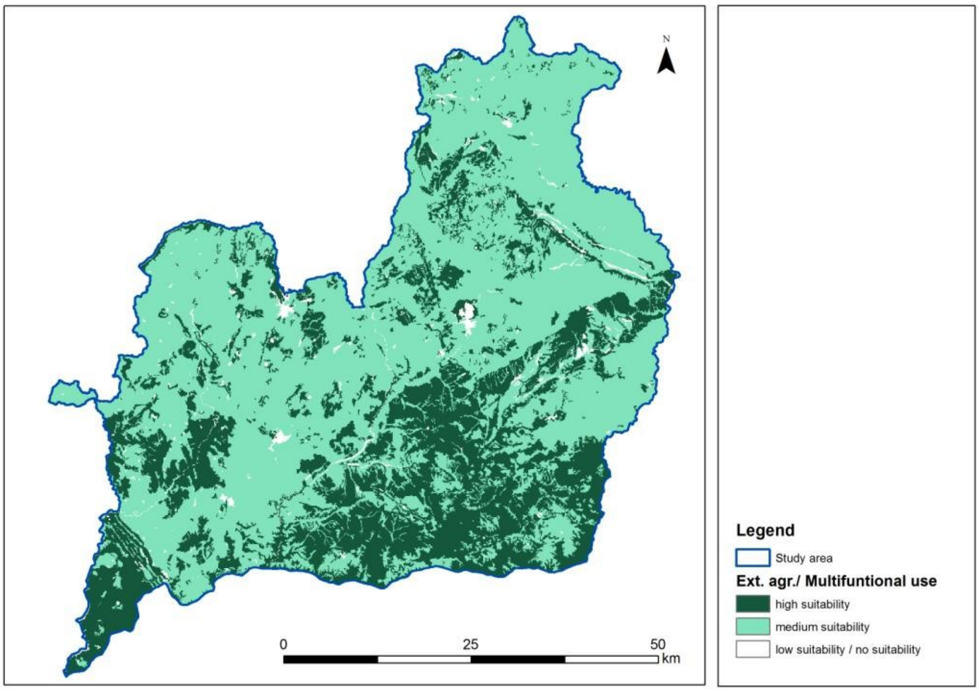


Figure 9: Suitability for Extensive agriculture/ Multifunctional use.

Figure 10 shows the degree of accordance between the soil potentiality and the land use resulting from local spatial analysis using combine tool.

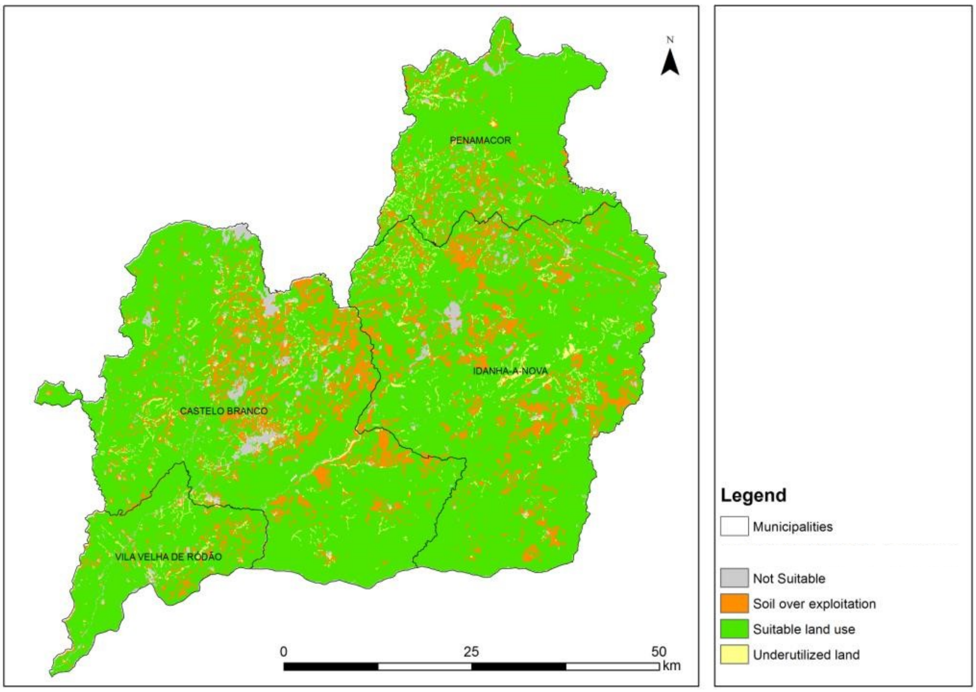


Figure 10: Soil potentiality vs. Land use

The use of GIS for identifying and mapping land use suitability was verified in this study. GIS is one of the mostly used technologies in land suitability mapping. The methodology presented in this paper using GIS and MCDA as a tool to aid decision-making process with particular case study of locating suitable areas for different agroforestal uses.

This methodology allows the correct evaluation of the natural suitability of the land, using a set of biophysical criteria. It contributes, also, to the discussion about the adequacy of current and future uses taking into account the environmental carrying capacity.

The implementation of this spatial data analysis approach could be a useful tool for stakeholders in land use planning and management.

ACKNOWLEDGEMENTS

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