IDENTIFICATION AND PHYSICAL-GEOGRAPHIC CHARACTERIZATION OF THE GRASSLANDS IN THE RETEZAT MOUNTAINS, THROUGH GEOMATIC TECHNIQUES AND MEANS

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Abstract. *Grasslands, as components of the land fund, can be considered some of the most important natural resources of rural areas, especially in mountain regions focused on subsistence agriculture. The spatial distribution of grasslands is conditioned by the physical-geographical factors, especially the relief, by altitude and the slope of the land. The identification and characterization of grassland areas in the Retezat Mountains, the purpose of the research presented in this paper, was made according to the Corine Land Cover database, 2018 edition. After the identification and location of the grasslands, the second stage of the research consisted in representing them according to the altitude of the study area. For this altitudinal gradient analysis, a Digital Elevation Model (DEM) was used with a spatial resolution of 25 m. In the next step, the grasslands of the area of interest were represented and classified according to the slope of the land, using the slope map generated from the DEM. ArcGIS 10.4 software was used for the analysis and cartographic representation of geospatial data (grassland surfaces, raster maps and other auxiliary vector data). The results obtained in this study demonstrated that the grasslands are well represented in the structure of the land fund of the Retezat Mountains and are unevenly distributed on the predetermined altitudinal levels. Depending on the established slope classes, considering the mountainous nature of the study area, grasslands were identified in variable conditions, in different proportions, on all slope intervals.*

Keywords: *grasslands, mountain area, altitudinal gradient, land slope*.

INTRODUCTION

In the economy of mountain regions, grasslands play a particularly important role in different aspects: biodiversity and landscape conservation (BAKKER, BERENDSE,1999; SMITH ET AL, 2003; COJOCARIU ET AL, 2018; VOGT, 2021); as a habitat for different species (SUTCLIFFE ET AL, 2015); as a direct and indirect source of income for the inhabitants of the respective areas (ROBINSON, SUTHERLAND, 2002; BROOM ET AL, 2013).

Over time, grasslands are subject to the action of natural and/or anthropogenic factors that lead to changes in their spatial distribution and decreases or increases in surface area. In this context, an increasingly important phenomenon in the landscape of mountain regions is the abandonment of agricultural lands and implicitly of grasslands, which leads to their afforestation or the transition to non-productive lands (BAUR ET AL, 2006; PIESSENS, HERMY, 2006; GUSTAVSSON ET AL, 2011; KIZEKOVÁ ET AL, 2018).

In view of the changes produced, it becomes absolutely necessary to monitor the pastoral space, especially in the mountainous regions, "fragile" regions from a socio-economic point of view, where the grasslands represent an important link of the local economy.

The monitoring of grasslands can be done by classical methods, however, in the last decades, various techniques and means of geomatics, photogrammetry, remote sensing and/or Geographic Information Systems (GIS) have been developed, which aim to both evaluate the land coverage/land use, as well as the appreciation of trends in the spatio-temporal dynamics of the various components of the land fund (GHOSH ET AL, 1996; SHALABY, TATEISHI, 2007;

BĂLTEANU, POPOVICI, 2010; COJOCARIU ET AL, 2015; CEGIELSKA ET AL, 2018; SIMON ET AL, 2018; MEHRABI ET AL, 2019).

In another context, the evolution and distribution of grasslands is closely dependent on the relief of the analyzed territory, which exerts its influence directly and/or indirectly, in particular, through the altitude, the slope and the orientation of the slopes (BENNIE, 2003; GONGA ET AL, 2008; LIEFFERS, LARKIN-LIEFFERS, 2011; LIEFFERING ET AL, 2019).

Starting from the previously mentioned hypotheses, the purpose of the research presented in this paper can be divided into two research directions: on the one hand, the analysis of the dynamics of grassland surfaces over time, in the period 1990 - 2018, and on the other hand, the characterization of the surfaces of grasslands in relation to the relief and slope of the land, some of the factors with a major impact on the typology and vegetation of the grasslands.

MATERIALS AND METHODS

Study area

For the delimitation of the study area, the Map of relief units from Romania, available in vector format on the geo-spaţial.org platform (Limits of relief units, authors: Candrea B., Candrea P., Niță M.), was used; in this layer, the physical-geographical region was made according to Posea Gr. and Badea L. (1984). According to the mentioned authors, the Retezat Mountains are divided into: the Retezat Massif (Figure 1 - the area of interest in this study), the Tulisa Mountains and the Piule-Iorgovanu Massif.

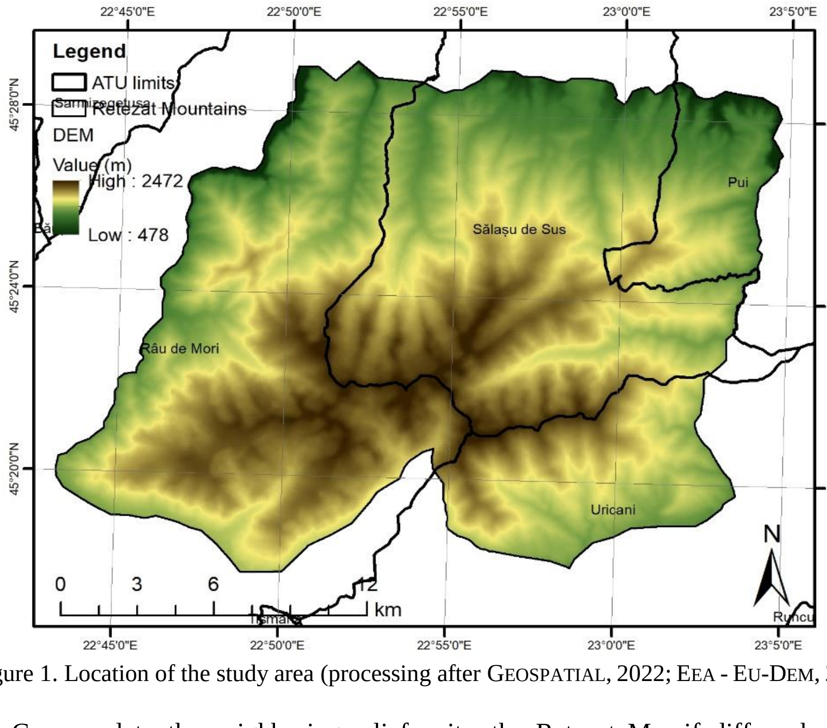

Figure 1. Location of the study area (processing after GEOSPATIAL, 2022; EEA - EU-DEM, 2022)

Compared to the neighboring relief units, the Retezat Massif differs, both from a geomorphological point of view, as well as from a petrographic and structural-tectonic point of view (URDEA, 2000). The limits of the massif are: to the north, the Hateg Depression, to the east, the Tulisa Mountains (border on the valleys of the Bărbat and Pilug rivers), to the south, the

Piule - Iorgovanu Massif (on the valleys of the Buta and Lăpuşnicu Mare rivers), and to the west, the Ţarcu Massif, the border being the valley of the Râul Mare (POSEA, BADEA, 1984).

The Retezat Massif is similar to a parallelogram (Figure 1) with a surface of approximately 413 km^2, which represents approximately 11% of the area of the Retezat - Godeanu Group and approximately 3% of that of the Southern Carpathians (URDEA, 2000). It extends from 478 m, especially in the southern part, at the contact with the Hateg Depression, to 2472 m, in the central area and is characterized by a great geological and geomorphological complexity.

Research methodology

The working methodology in this study was staged as follows (Figure 2):

1. Analysis of changes in grassland areas - stage in which two data sets from the Corine Land Cover collection were analyzed, for the years 1990 and 2018 (COPERNICUS LAND MONITORING SERVICE, 2022); in this way, the dynamics of the land use categories and especially of the grassland areas, at the level of the analyzed area, were followed;

2. Processing of geospatial datasets for the analysis of grasslands – in this stage, the geospatial and statistical data related to:

- altitude - a Digital Elevation Model (DEM) was used with a spatial resolution of 25 m (EUROPEAN ENVIRONMENT AGENCY, 2022) which was later reclassified into five altitude classes, respectively 479–600 m, 601-800 m, 801-1000 m, 1001-1600 m and 1601-2472 m;
- slope – based on the DEM, the slope map was generated (in degrees) and its reclassification was applied into four slope groups, respectively 0 - 15º, 16 - 30º, 31 - 45º and 46 - 60º;
- grassland areas - the map of land use in 2018 was used, from which only the areas used as grasslands were extracted;

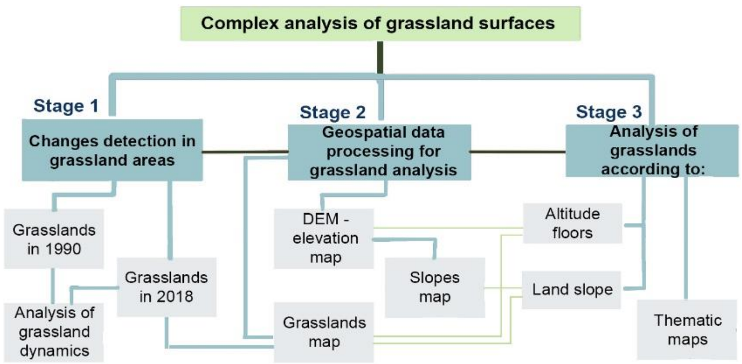

Figure 2. Work methodology

3. Analysis of grasslands on altitudinal levels and slope classes - it was done by overlay analysis, in the ArcGIS 10.4 software - the Tabulate Area function (ARCGIS DOCUMENTATION, 2022); at this stage, statistical analyzes were generated and cartographic materials.

RESULTS AND DISCUSSIONS

Analysis of changes in the dynamics of grassland surfaces

For the identification and analysis of the spatial distribution of grasslands, in the case of this study, the Corine Land Cover database, 1990 and 2018 editions, was used. This collection of land cover data is widely used both in Romania and at the international level (BĂLTEANU,

POPOVICI, 2010; POPOVICI ET AL, 2013; MISHRA ET AL, 2014; HANGANU, CONSTANTINESCU, 2015; COPACEAN ET AL, 2019).

In the vegetation cover of the Retezat Massif, in close correlation with the land use, forests and grasslands predominate and in the high regions, rocky lands, devoid of vegetation (Figure 3). The stratification by altitude preserves, in general, the structure of the vegetation cover of the Southern Carpathians (TARZIU, DINCA, 2002): mixed forest floor (550-800 m), beech floor (700-1200 m), conifer floor (1000-1750 m), the floor of the alpine hollow and that of the cliffs (1700-2500 m), divided into two sub-floors: the lower one, dominated by junipers and the upper one, dominated by dwarf bushes.

Grasslands are located in all levels of vegetation, from the lowest altitudes, to the area of the alpine gap. These are grasslands with High Natural Value (HNV), which means a high degree of species diversity (IONESCU, OSICEANU, 2007; AKEROYD, PAGE, 2011; VÎNTU ET AL, 2011; NITA ET AL, 2019; RANTA ET AL, 2021).

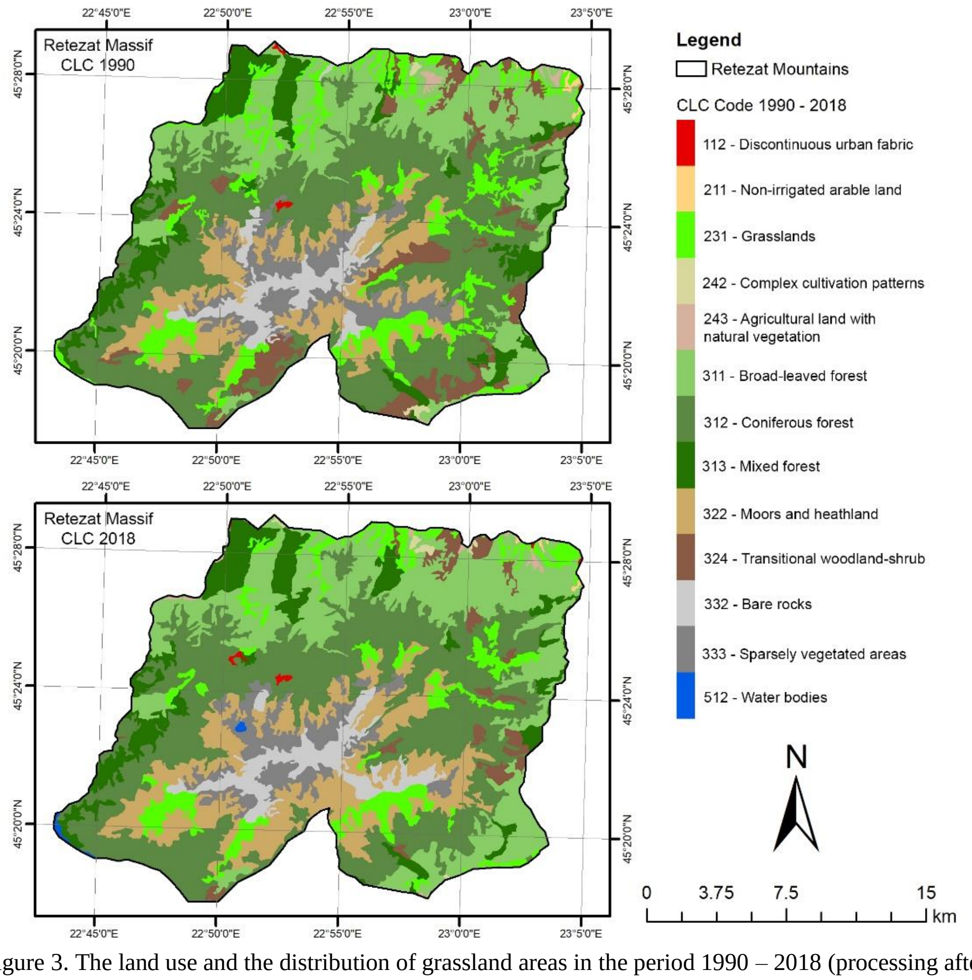

Figure 3. The land use and the distribution of grassland areas in the period 1990 – 2018 (processing after GEOSPATIAL, 2022; COPERNICUS LAND MONITORING SERVICE, 2022)

In general terms, the spatial distribution of grasslands keeps the same trend, in both years considered (Figure 3)

The analysis of surface dynamics for each land use category, between 1990 and 2018 (Table 1), according to CLC data, highlights the following aspects:

- significant reduction of the areas used as arable land, by 44.43%; considering the mountainous character of the study area, arable land occupies very small areas (35.64 ha), less than 1% of the total area, and their reduction can be explained by the abandonment of these lands and the transition to other categories of use (pastures, lands with shrubby vegetation, etc.);
- significant reduction, by 60.18%, of lands occupied by shrubby, transitional vegetation (324 CLC code); these lands were assimilated at the end of the analyzed period, most likely, to forest use categories;

Table 1

The dynamics of surfaces by land use categories in the interval 1990 - 2018

CLC Code	Land use	Area in 1990 (ha)	Area in 2018 (ha)	Difference 2018 - 1990 (ha)	Relative increase/ decrease (%)
112	Discontinuous urban fabric	56.54	66.61	10.07	17.81
211	Non-irrigated arable land	64.13	35.64	-28.49	-44.43
231	Pastures	4241.42	3352.64	-888.78	-20.95
242	Complex cultivation patterns	80.32	106.21	25.89	32.23
243	Agricultural land with natural vegetation	133.91	140.72	6.81	5.09
311	Broad-leaved forest	7672.45	9087.04	1414.59	18.44
312	Coniferous forest	13880.14	14071.61	191.47	1.38
313	Mixed forest	3459.99	3318.24	-141.75	-4.09
322	Moors and heathland	4520.34	5803.52	1283.18	28.39
324	Transitional woodland-shrub	2786.45	1109.70	-1676.76	-60.18
332	Bare rocks	1707.37	1884.75	177.37	10.39
333	Sparsely vegetated areas	2688.39	2232.73	-455.65	-16.95
512	Water bodies	80.21	82.90	2.69	3.35

- the areas used as grasslands were reduced quantitatively by 20.95%; in 1990, they occupied 10.27%, and in 2018, they extended over 8.11% of the total area; obvious changes occurred, especially in the lower areas, their place being taken by forest surfaces (Figure 3).

Analysis of grassland areas in relation to the altitude and slope of the land

For the analysis of grasslands in relation to altitude, the Digital Elevation Model was classified into five altitude groups. According to this criterion, the lands used as grasslands were identified in all altitudinal levels (Figure 4), but in different proportions (Table 2).

Also, for the analysis of grasslands according to the slope of the land, the slope map, generated from the DEM and expressed in degrees, was reclassified into four slope groups. Through the overlay analysis, the existence of grasslands was highlighted in all slope groups (Figure 5), in different proportions (Table 2).

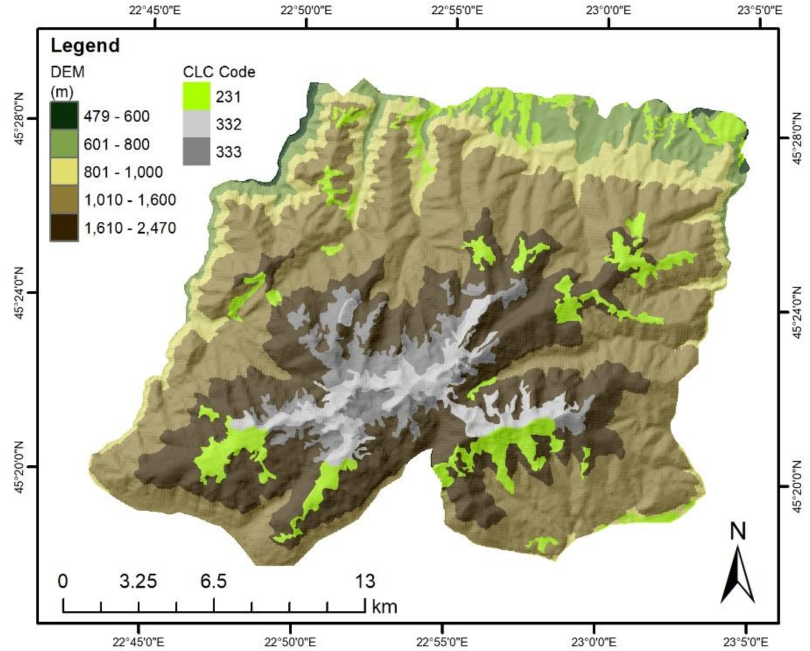

Figure 4. The distribution of grasslands on altitudinal floors (processing after GEOSPATIAL, 2022; EEA - EU-DEM, 2022; COPERNICUS LAND MONITORING SERVICE, 2022)

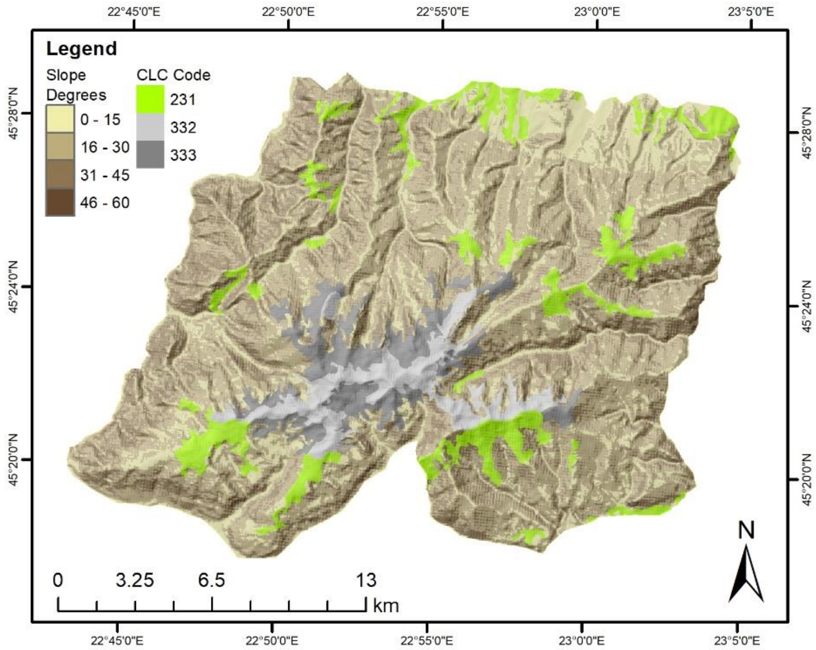

Figure 5. The distribution of grasslands by slope classes (processing after GEOSPATIAL, 2022; EEA - EU-DEM, 2022; COPERNICUS LAND MONITORING SERVICE, 2022)

Table 2

Classification of grasslands by altitude and slope categories

Altitude floor (m)	Grasslands		Slope classes (Degrees)	Grasslands	
	(ha)	(%)		(ha)	(%)
478 - 600	19.13	0.57	0 - 15	1372.44	40.95
601 - 800	655.69	19.56	15.1-30	1604.44	47.87
801 - 1000	269.44	8.04	30.1 - 45	371.88	11.09
1001 - 1600	589.31	17.58	45.1 - 59	1.94	0.06
1601 - 2472	1818.19	54.25			
The total area of grasslands: 3352.64 ha					

The data presented in Table 2 show that half of the grasslands of the Retezat Massif (54.25%) are located at over 1600 m altitude, being thus included in the category of alpine grasslands, with a high degree of biodiversity.

Approximately 45% of the grassland areas are located between 600 - 1600 m altitude, integrated in the forest floors. They are grasslands with a great diversity of species and of particular importance in the economy of the area.

Approximately 89% of the analyzed grasslands are located on land with a slope between 0 - 30º. In this context, slope processes, such as erosion or landslides, can occur on a large part of them.

Although the analyzed grasslands are located in the mountainous area, in most cases, the slope of the land does not prevent their exploitation through grazing and mowing.

CONCLUSIONS

Grasslands represent an important component of the land fund in the Retezat Massif, both from a socio-economic point of view and through spatial distribution, being located in all the component sub-zones of this mountain area.

The spatio-temporal analysis of land use, at the level of the Retezat Massif, showed a significant reduction of the areas used as arable land, of those occupied by shrubs, transitional vegetation and the areas of grasslands. These reductions are generally explained by the abandonment of agricultural land, which implies the expansion of forest formations.

Depending on the altitudinal gradient, it was found that 54.25% of the grassland areas are located at over 1600 m altitude, being thus included in the category of alpine grasslands, with a high degree of biodiversity (High Natural Value grasslands).

Considering the mountainous nature of the study area, approximately 60% of the grasslands are located on slopes over 15º. However, the grasslands, regardless of the slope, are used in a multifunctional way, depending on the needs of the local communities.

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