INVENTORY OF GRASSLAND SURFACES IN THE CRÍSUL ALB HYDROGRAPHIC BASIN, USING GIS TECHNIQUES

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Abstract. Grasslands (pastures and hayfields) can be seen as the main natural resources of rural territories, considering the predominantly agricultural profile of these areas. In this context, the present study has as its main purpose the inventory of grassland areas in the Crişul Alb river basin and their relationship with certain components of the natural environment (altitude, slope, relief unit and so on). The Corine Land Cover database, 2018 edition, was used to identify and locate the grassland areas, and the data and spatial analyzes were carried out in the GIS environment. The analyzed area has a total surface of 422798 ha, and grasslands were identified on 61250 ha, which represents 14.49% of the total. In terms of territorial distribution, the areas used as grasslands can be found in all relief forms and units, in different proportions, but a greater concentration of them was observed in the Crişurilor Plain, in the Cigherului Hills and in the Zarandului Depression. In terms of altitude, the study area falls between 82 - 1587 m, with significant grassland areas being concentrated, for the most part, in the lower altitudinal levels. In the case of areas used as grasslands, the slope of the land, one of the most important limiting factors, has different values, depending on the sub-area and the relief conditions. Overall, in the study area, grasslands are well "represented", especially in its western half, the eastern half being dominated by forest areas.

Keywords: grasslands, spatial distribution, watershed.

INTRODUCTION

Regardless of the geographical area in which they are located, grasslands are of major importance, at the local, regional or national level, through the lens of several aspects: they provide fodder for raising animals (EMANUELSSON, 2009), they are characterized by a great diversity of flora (VÎNTU ET AL, 2011; AKEROYD, PAGE, 2011; HOANCEA ET AL, 2017; COJOCARIU ET AL, 2019; NITA ET AL, 2019), are considered a living environment for different species of plants and animals (SUTCLIFFE ET AL, 2015), but they are also particularly important elements from a landscape point of view.

The technical and technological progress registered in the last decades and in particular, the possibility of using satellite images, made it possible to analyze grasslands in a multidisciplinary context, with an increasingly high degree of complexity and precision. In the case of grasslands, the following aspects can be analyzed "remotely": the spatial distribution of species (ZIMMERMANN, KIENAST, 1999; COJOCARIU ET AL, 2018; HARSHIT, JEGANATHAN, 2019), the distribution of types of meadows (DIXON ET AL, 2014), invasive species monitoring (HELLESEN, MATIKAINEN, 2013), mapping and analysis of changes in grassland areas and land use in general (BĂLTEANU, POPOVICI, 2010; POPOVICI ET AL, 2013; IFTIKHAR ET AL, 2016; TARANTINO ET AL, 2016; CEGIELSKA ET AL, 2018; KIZEKOVÁ ET AL, 2018; SIMON ET AL, 2020).

For the inventory and representation of land use and implicitly grassland areas, geospatial data sets, with different resolutions, can be used, such as Global Land Cover 2000 (BARTOLOME, BELWARD, 2005) or ESA Glob Cover 2005 (DEFOURNY ET AL, 2006), but one of the most frequently used is the Corine Land Cover database, with a spatial resolution of 25 m, which also allows analysis at regional level (HANGANU, CONSTANTINESCU, 2015; MEHRABI ET AL, 2019; RUSU ET AL, 2020; KHOSHNOOD MOTLAGH ET AL, 2021; LIU ET AL, 2023).

The purpose of the research followed two directions: (1) the inventory of the grassland areas in the Crişul Alb river basin and (2) the analysis of the grasslands in relation to some of the most important environmental factors, namely the altitude and the slope of the land.

MATERIALS AND METHODS
Study area

The research presented in this study concerned the hydrographic basin (H.B.) of the Crişul Alb river (Figure 1), with a total area of 422798 ha. H.B. Crişul Alb overlaps, for the most part, Arad county, and in the southeastern part, Hunedoara county; in the east, on very small areas, it extends in Alba county, and in the north, also on a small area, in the territory of Bihor county.
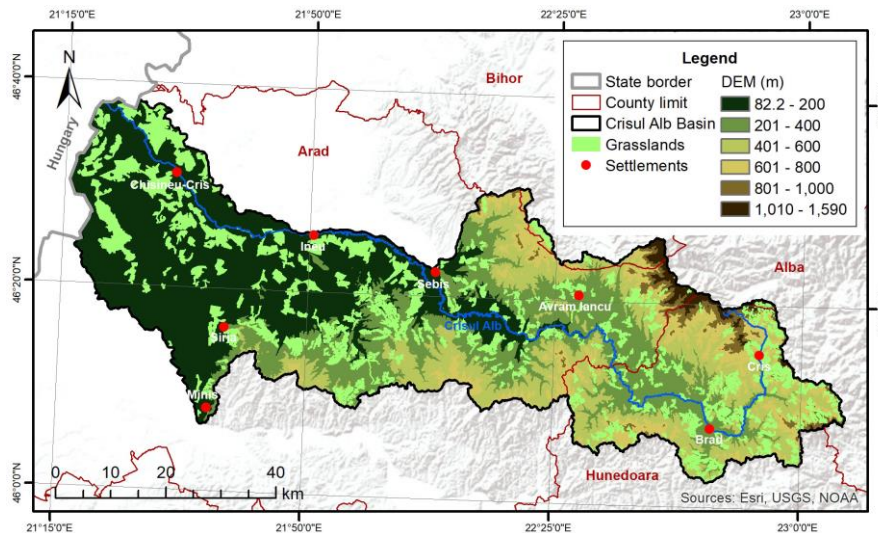

Figure 1 Location of the study area – H.B. Crişul Alb (processing after: GEOSPATIAL, 2022; EEA - EU-DEM, 2022; COPERNICUS LAND MONITORING SERVICE, 2022; ABA CRIŞURI, 2023)

On the territory of H.B. Crişul Alb, the relief is displayed between 82 - 1590 m (Figure 1). The altimetric balance shows, however, that 42% of the territory is below the altitude of 200 m and 25% between 201 and 400 m, which indicates the hilly character of the relief. Altitudes above 801 m are found on 4% of the total area, in the Bihor Mountains.

In accordance with the physical-geographical conditions, the grassland areas are distributed throughout the analyzed area, especially in the plain and hill area, on the total area of 61250 ha (COPERNICUS LAND MONITORING SERVICE, 2022), which represents 14.49% of the area total of the Crişul Alb basin.

Research methodology

The research presented in this paper was carried out according to the scheme from Figure 2. ArcGIS 10.4 software was used to process geospatial data and generate cartographic materials (ARCGIS DOCUMENTATION, 2022).

1. The processing of the Corine Land Cover (CLC) database, to extract the areas used as grasslands, at the level of 2018. The areas used as secondary pastures (code 231) and

natural grasslands (code 321) were taken into account. All spatial entities were united in a single spatial "geometry" and thus resulted the unitary surface used as a grassland. In a previous stage of the research, the working algorithm was also applied to the CLC data set from 1990, to generate the analysis of changes and identify the areas of wooded grasslands.
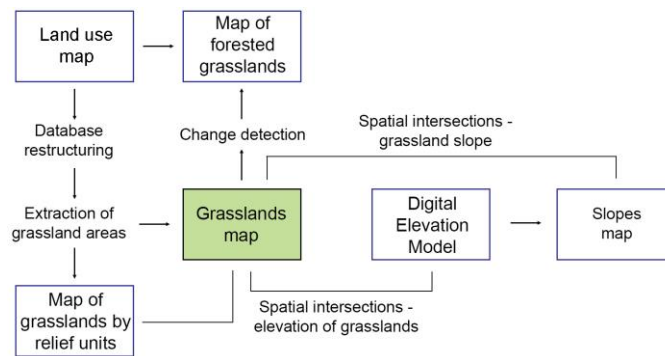
Figure 2 Work methodology

2. The analysis of grasslands according to the relief units assumed the overlap of the grassland surfaces with the map of the relief units, in vector format (POSEA, BADEA, 1984). The proportion of grasslands, relative to their total surface, in each relief unit and their participation in the surface of each relief unit was calculated;

3. The analysis of grasslands on altitudinal gradient assumed, in the first phase, the processing of the Digital Elevation Model (DEM), with a resolution of 25 m (EEA – EU-DEM, 2022). The altitudinal model was reclassified into six classes: 82–200 m, 201–400 m, 401–600 m, 601–800 m, 801–1000 m and 1001–1590 m. After the reclassification, the altitudinal model was "intersected" with the areas of grasslands, through the *Tabulate Area* function, thus quantifying the cantoned grasslands in each altitudinal level.

4. The analysis of meadow areas according to the slope of the land was carried out on the basis of the slope map (in degrees) generated from the DEM. The map has been reclassified into six slope classes: 0-5°, 5.01-10°, 10.1-15°, 15.1-20°, 20.1-30°, 30.1-59.4°. Through *Tabulate Area*, the intersection with the grassland surfaces was made and thus their framing was made according to the slope classes.

RESULTS AND DISCUSSION
Inventory of grassland areas in the Crişul Alb basin
In terms of land use/land cover (LULC), at the level of H.B. Crişul Alb (Figure 3), the situation was as follows: 41.67% forest areas, 28.37% arable land, 14.49% grasslands, 7.83% areas with complex crops, 3.84% built space, 1.18% fruit plantations. On areas below 1% are found: areas with various human activities, rice fields, vineyards, areas with shrubs and water surfaces.

In terms of the territorial distribution of the land use classes, the eastern half of the analyzed territory, including the mountainous and high hill area, is dominated by forests, and in the western half, overlapping the plains and low hills, arable land predominates (Figure 3).
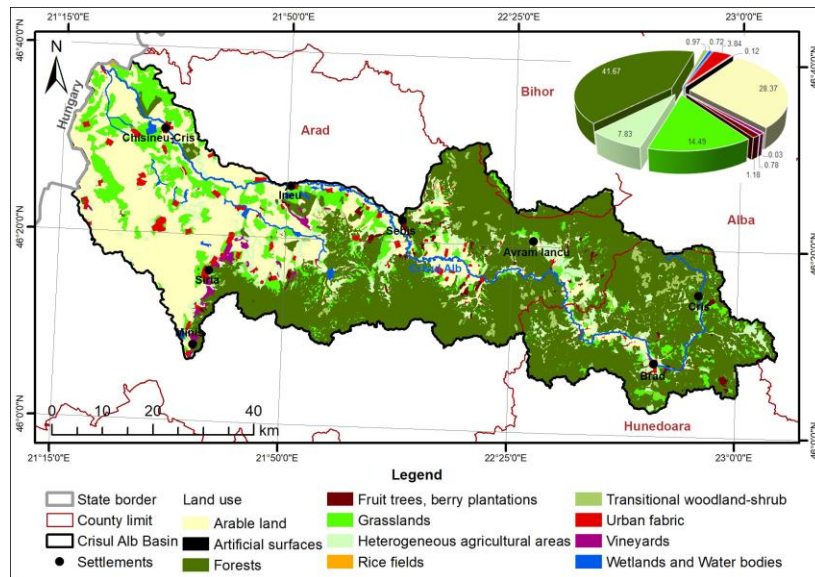
Figure 3 Land use in H.B. Crişul Alb (processing after GEOSPATIAL, 2022; COPERNICUS LAND
MONITORING SERVICE, 2022; ABA CRIŞURI, 2023)

Grasslands, with a total area of 61250 ha, are present in all forms of relief, with less
participation in the high mountain area and with a greater concentration in the low, plain area
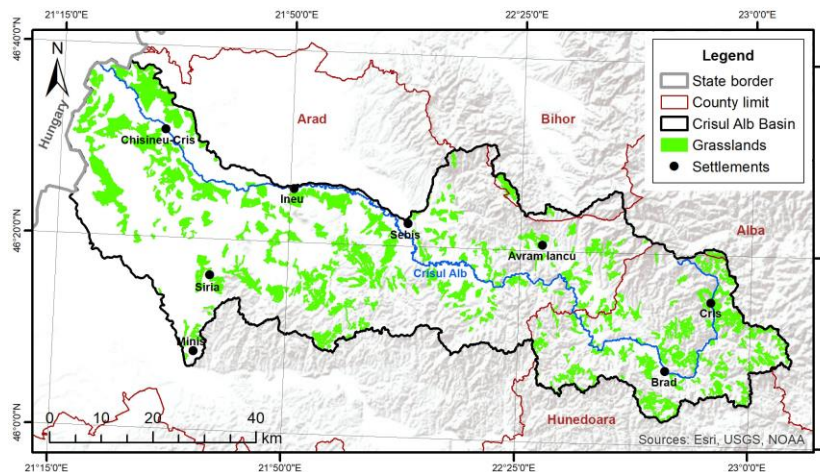(Figure 3, Figure 4).

Figure 4 Areas of grasslands in H.B. Crişul Alb (processing after GEOSPATIAL, 2022; COPERNICUS LAND
MONITORING SERVICE, 2022; ABA CRIŞURI, 2023)

Analysis of grasslands by relief units

At the level of H.B. Crişul Alb, according to the regionalization carried out by Posea
and Badea (1984), the following relief units were identified (Figure 5): in the west, the
Crişurilor Plain (78421 ha, 19%) and the Mureşului Plain (43270 ha, 10%); in the east, Brad-

Hălmagiu Dep. (41740 ha, 10%) and in the central area, Zărandului Dep. (30645 ha, 7%); in the central area, the Cigherului Hills (49025 ha, 12%) and the Codru-Moma Hills (17222 ha, 4%); in the north and northeast, the Codru-Moma Mountains (32092 ha, 8%) and the Bihor Mountains (40339 ha, 10%), and in the southeast and south, the Metaliferi Mountains (53183 ha, 13%) and the Zărandului Mountains (36767 ha, 9%).
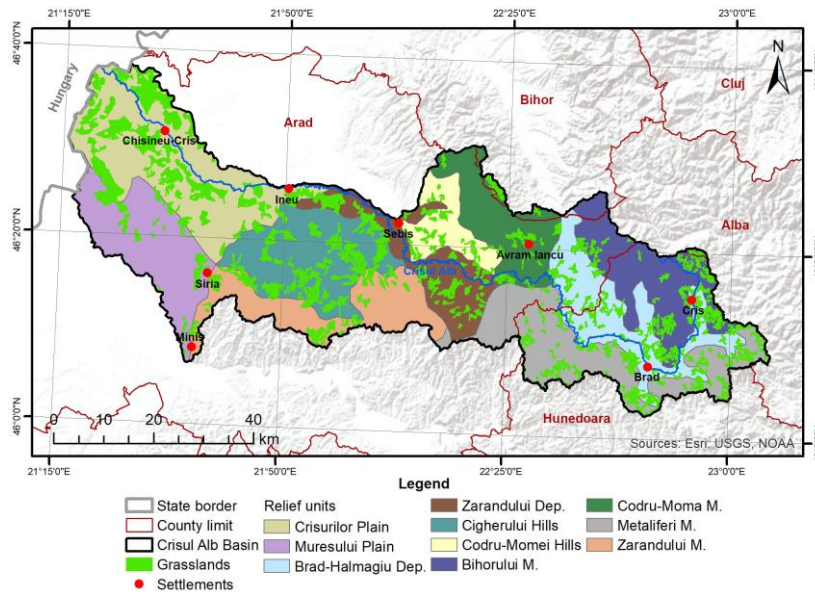

Figure 5 Relief units from H.B. Crişul Alb (processing after GEOSPATIAL, 2022; COPERNICUS LAND MONITORING SERVICE, 2022; ABA CRIȘURI, 2023)

Of the total grassland areas, 33% are located in Crişurilor Plain and cover 26% of the area of this unit. A significant percentage of grasslands is also found in the Cigherului Hills, respectively 15% of the total and covers 19% of the area of the hill unit. Also, 10% of the analyzed grasslands are located in the Brad-Hălmagiu Dep., which means 14% of the territory related to the depression (Figure 6).
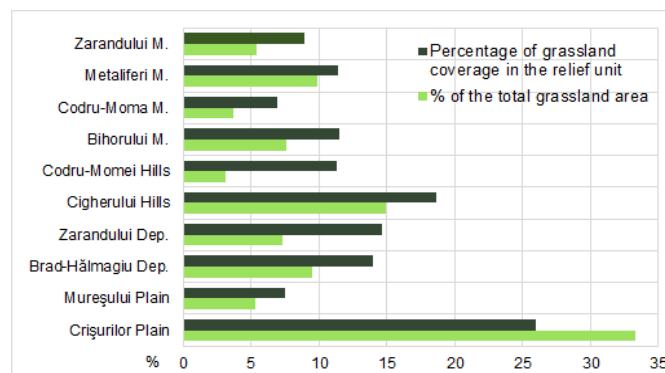

Figure 6 The distribution of grassland areas by relief units

Among the mountain units, grasslands are found on the largest surfaces in the Metaliferi Mountains, respectively 10% of the total surface and cover 11% of the surface of these mountains.

As found in the case of other regions (BAUR ET AL, 2006; DRĂGAN ET AL, 2020), and in the case of the study area, the grassland surfaces are marked by afforestation processes (Figure 7). The analysis of changes based on the CLC data sets from 1990 and 2018, demonstrated that 2990 ha of grasslands have become forested, a phenomenon reported especially in hilly and mountainous areas. The phenomenon occurs against the background of the abandonment of grasslands, either as a result of a deficient demographic balance, or by reorienting the agricultural activities of local communities.
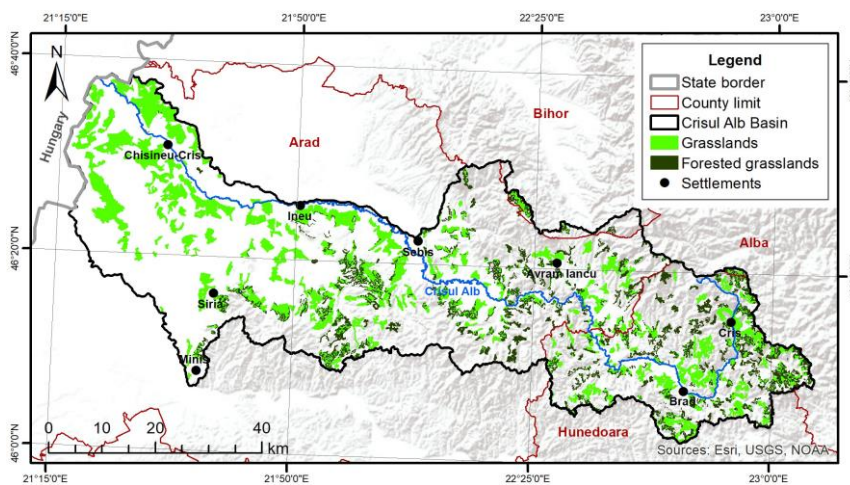

Figure 7 The distribution of wooded grasslands at the level of H.B. Crişul Alb (processing after GEOSPATIAL, 2022; COPERNICUS LAND MONITORING SERVICE, 2022; ABA CRIŞURI, 2023)

Also, also as a result of the abandonment of the grasslands, they turned into lands with transitional shrub vegetation, on a net surface of 731 ha, a phenomenon that can be considered the initial phase of the afforestation of the grasslands.

Analysis of grasslands on altitudinal gradient

The analysis of the distribution of grasslands according to the predetermined altitudinal levels is presented synthetically in Figure 8.

It is demonstrated that the relief, through altitude, slope or exposure of the slopes, influences, directly and indirectly, both the vegetation of the grasslands and their evolution (LIEFFERING ET AL, 2019).

The correlation between grasslands and altitude highlighted the following aspects: 52% of the grassland areas are located at altitudes between 82 - 200 m and cover 18% of the area of the respective floor, dominated mainly by arable land; 27% of the grasslands are located at altitudes between 201 - 400 m and occupy 16% of the surface of the respective floor; 10% of the total grassland areas are concentrated in the 401 - 600 m floor, and the weight in its area drops to 8%, with forest areas being dominant.
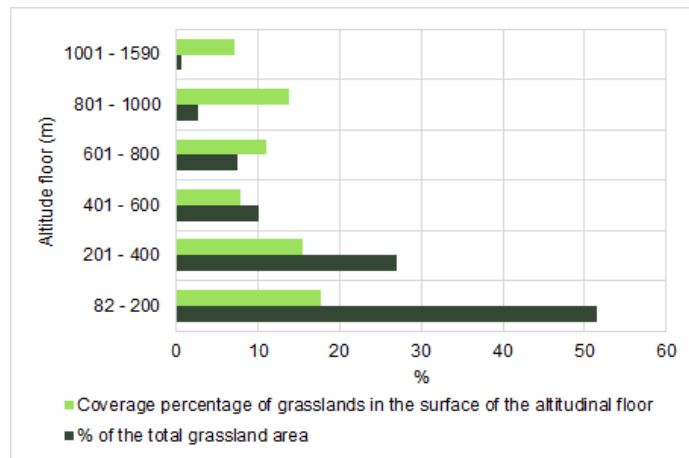
Figure 8 Correlation grasslands - altitudinal floors

Above the altitude of 600 m, the participation of grasslands is significantly reduced, in the structure of the land base, forests are dominant.

Analysis of grassland areas depending on the slope of the land

The slope of the land, one of the factors with a direct and indirect influence on the grasslands, has maximum values (59º) in mountainous and high hill areas and minimum values (0º) in low plain areas (Figure 9).
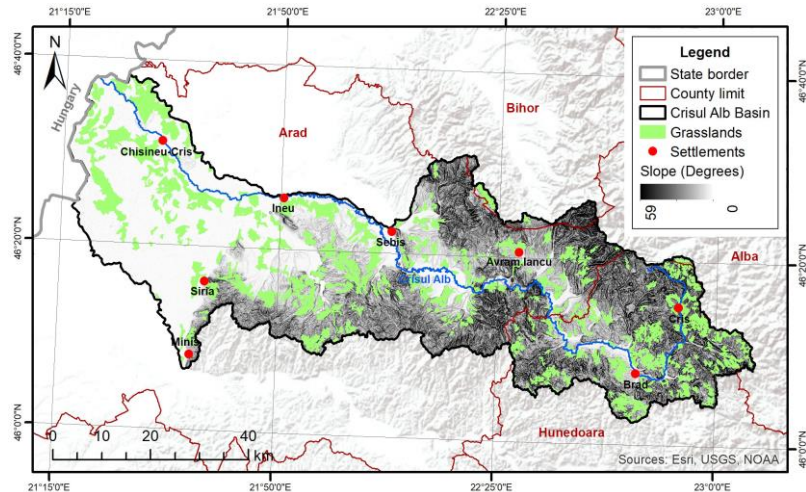

Figure 9 The distribution of grassland areas according to the slope of the land (processing after GEOSPATIAL, 2022; COPERNICUS LAND MONITORING SERVICE, 2022; ABA CRIŞURI, 2023)

According to the pre-established slope classes, the grassland areas are classified as follows (Figure 10): 60% of them are grafted on land with a slope between 0 - 5º; 19% of the grasslands have a slope between 5.01 - 10.0º and 12% are grasslands with a slope between 10.1 - 15.0º. Approximately 10% of the analyzed grasslands have a land slope greater than 15º and are located, mainly, on the slopes of high hills or in mountainous areas.
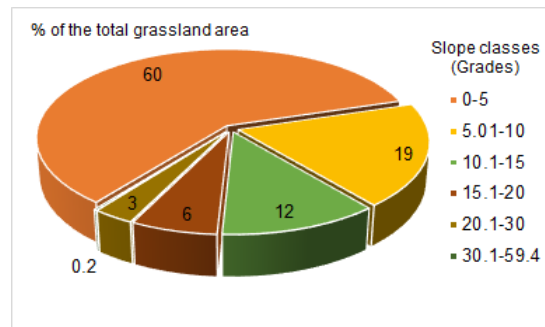
Figure 10 Grouping of grassland areas (ha) according to the slope of the land (°)

The data from the specialized literature demonstrated the fact that the slope of the land has an influence, both on the distribution of plant species in the grasslands (BENNIE, 2003; LIEFFERS, LARKIN-LIEFFERS, 2011) and on the productivity (GONGA ET AL, 2008).

CONCLUSIONS

On the territory of H.B. Crişul Alb, the grassland areas represent 14.49% of the total, a value comparable to that recorded at the national level. From the point of view of spatial distribution, they are especially concentrated, in the western half, in plain areas and low hills, the mountainous areas being dominated by forest areas.

The analysis of the spatio-temporal changes produced in the case of grasslands, between 1990 and 2018, highlighted the manifestation of their afforestation processes (2990 ha) or transition to the class of land with transitional shrub vegetation, a consequence of the abandonment of the pastoral environment.

Of the total area of the grasslands analyzed, 79% are located at altitudes below 400 m, which means that they "benefit" from optimal environmental and exploitation conditions. Among the grasslands of the considered territory, 60% are grafted on land with a slope below 5° and 19% on land with a slope between 5.01 - 10.0°, which means that the slope of the land is not a limiting factor in the case of grasslands.

The involvement of GIS techniques and geospatial data in the inventory and representation of grassland areas offers numerous advantages: the possibility of applying multilayer analyses, holistic analysis of grasslands in correlation with other environmental factors, cartographic representation and interpretation of maps, to extract specific or overall information.

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