APPLICATION OF GIS IN GEOECOLOGICAL EVALUATION OF TERRAIN – CASE STUDY NATURE PARK HUTOVO BLATO

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Abstract

Application of GIS in geoecological evaluation of terrain – case study nature park Hutovo blato

The subject of the research is the application of GIS in geoecological evaluation of terrain – case study Nature Park Hutovo blato. Geoecological evaluation of terrain is strongly relevant methodological procedure, which can be used for acquiring results about real value of particular areas. Method of terrain evaluation is also used, through five categories: hypsometric characteristics, angle of slopes, vertical dissection, terrain mobility and vegetation cover. The aim of the research is to clarify how valuable and useful certain segments of the terrain are for the purpose of spatial planning – for the tourism valorization, construction of various objects etc. Paper consists of several parts. First part defines the exact area of exploration. In the second part geomorphological characteristics of the researched area were analyzed. Geoecological evaluation of terrain, performed in third part was based on previous geomorphological analysis as well as bonity categories. Methods used in this paper are: analysis, synthesis, statistical method and cartographic method. Complete analysis was conducted using GIS.

Keywords

GIS, geoecological evaluation, Nature Park, spatial planning, Hutovo blato

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1. Introduction

The subject of this paper is the geo-ecological evaluation of the relief of the Hutovo Blato Nature Park. Geoecological evaluation of the natural environment is one of the practical geoecological methods suitable for optimal spatial management planning (Mamut 2010a; Hrelja 2017). The aim of such research is to determine the value of certain parts of protected natural areas, ie to determine the advantages and limitations of the environment for a particular social activity, from the aspect of its valorization for various economic activities, primarily for tourism, sports and recreation, construction, agricultural use, vegetation growth and its exploitation (Bognar 1990; Mamut 2010b). Apart from the purpose of economic exploitation, geoecological evaluation is also carried out with the aim of protecting the environment, ie planning the sustainable development of protected natural areas. In this regard, a geoecological evaluation of the Nature Park Hutovo Blato was conducted in this paper, based on the analysis of its geomorphological and vegetation characteristics.

The methodological concept of the research realization is defined in accordance to the set goals and tasks. These are primarily related to geo-ecological evaluation of the relief for the purpose of spatial planning - case study of Nature Park Hutovo blato. Number of methods and methodological procedures were used in the study, all of which ultimately gave a complex result. Research on this topic was conducted in several phases:
- The first phase of the research involves the collection of relevant literature, analysis and geo-ecological evaluation of the relief.
- The second phase of the research involves a detailed analysis of the relief through the component morphometric and vegetation characteristics.
- The third phase of the research consists in combining the analyzed contents and their complex systematization, and defining the geo-ecological value of the relief on the territory of the Nature Park Hutovo blato.

2. Geographical position of Hutovo blato

Nature Park Hutovo blato is located in the southern part of Bosnia and Herzegovina, in the physionomic region of Low Herzegovina (Fig. 1.). It is located east of the lower Neretva, in the Čapljina-Hutovo crypto-depression. Administratively, NP Hutovo blato belongs to three municipalities: Čapljina, Stolac and Neum. It is located east of the regional road Čapljina-Metković, and south of the main asphalt road Čapljina-Stolac.

The wider area of the Park is predominantly built of upper cretaceous layered limestone and dolomite, water-permeable rocks represented by aquifers of fissure-cavernous porosity. In addition to the above, quaternary, upper eocene and paleocene deposits are present in the central, southern and southeastern part of the study area.

The Hutovo Blato complex is not a single entity, it is divided into two parts by a limestone ridge: Gornje or Deransko Lake and Donje Lake or Svitavsko Blato. Gornje Blato covers the area of 2,130 ha (Hrelja 2017).

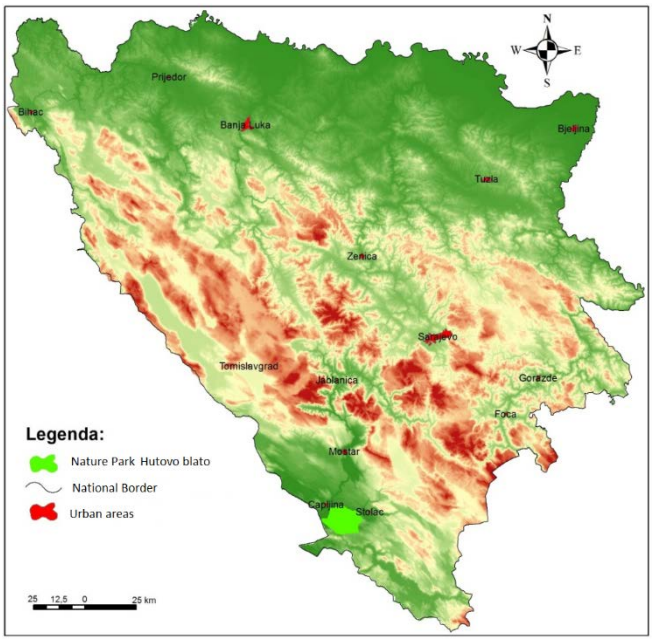

Fig. 1: Geographical position of NP Hutovo blato.

In terms of geomorphology, the NP Hutovo Blato belongs to the macroregion of the External Dinarides, within which it stands out with its specific accumulation-tectonic relief (Lepirica 2012).

The aquatic complex of Hutovo blato at the end of the tertiary was affected by strong orogenic tectonic movements. The tectonic descents of this area continued even after the pleistocene, and the crypto-depression of Hutovo blato is undoubted evidence for the neotectonic subsidence of the terrain.

Due to the predominant limestone composition of the terrain, the Hutovo Blato basin does not have developed surface hydrographic network. In terms of hydrography, surface and groundwater belong to the immediate Neretva river basin, i.e. the Adriatic Sea basin.

Hutovo blato belongs to Mediterranean climate type with mild winters and long, warm summers, or according to the Köppen-Geiger classification, to Cfa climate type (moderately warm and humid climate with hot summers). The value of average annual isotherms is 12.5 °C. The lowest temperatures are in January (2°C), and the highest in August (24°C). Annual precipitation is 1,640 mm (Hrelja 2017).

The analysis of vegetation cover on the vertical profile clearly distinguishes vegetation belts from wetlands, heaths and sclerophilous vegetation at the lowest hypsometric levels along the aquatic complex of Hutovo blato, over natural pastures, transitional forest area – overgrowth and shrubby vegetation to deciduous forests at the highest zones.

3. Research methodology

The geoecological analysis of the terrain was conducted on the basis of detailed geomorphological and vegetation research and mapping, and is the basis for the assessment of complex, multidisciplinary management of the natural environment in protected natural areas. Geoecological evaluation of relief is based on the methodology of grading morphological features of protected areas by categories of absolute heights, terrain slopes, vertical dissection and slope mobility (Bognar, Bognar 2010; Mamut 2010b).

In the evaluation procedure, a spatial matrix structured from a network of unit areas of 250 m^2 (i.e. 1 x 1 cm on a 1:25 000 map) was used. Its overlap with analytical maps of slopes, vertical dissection and hypsometric characteristics of the terrain provides a closer insight into the geomorphological features of individual parts of the protected area. In the first grading phase, each unit area was awarded the appropriate number of points according to the criterion of representation (share) of each of the analyzed morphological categories - altitude, slope, relief energy and slope mobility (Fig.2.).

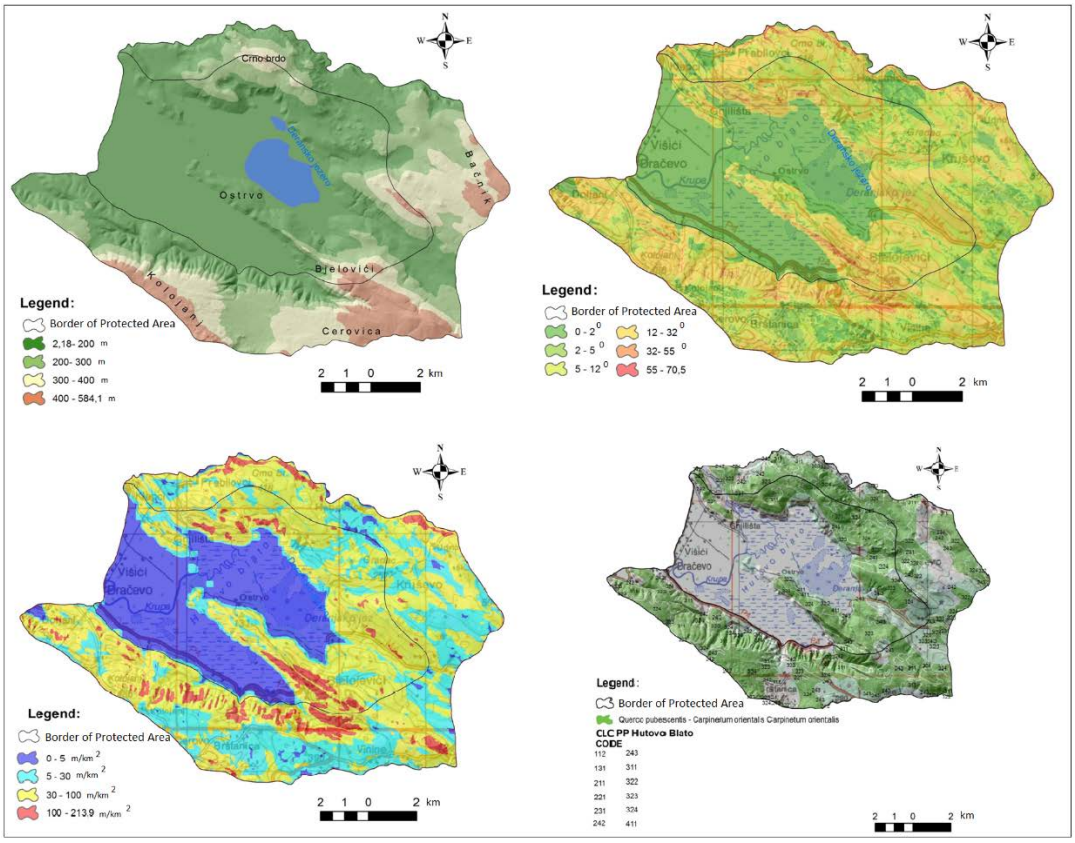

Fig. 2: Analysis of geomorphological and vegetation characteristics of NP Hutovo Blato.

Slope mobility is graded according to the potential mobility conditioned by a certain slope inclination (according to: Bognar, Bognar 2010):

- $0\text{-}2^0$ stable slope;
- $2\text{-}5^0$ slope wash poorly expressed;
- $5\text{-}12^0$ intensive slope wash;
- $12\text{-}32^0$ intensive slope wash and strong erosion;
- $32\text{-}55^0$ slope material removed, slopes mostly bare;
- $> 55^0$ landslides appearance.

The basic assumption is that the areas of the lowest slopes, lowest altitude, with the smallest vertical dissection and stable slopes are the most valuable living areas, so they get the highest number of points (100), 25 points for each indicator (25 x 4 = 100). Each unit area can receive a maximum of 100 points (if all four indicators are in the first category) and a minimum of 16.4 points (if all four indicators are in the sixth category) (Mamut, 2010a, 2010b) (Tab.1.).

By adding up the points by defined categories, the relief was ranked according to the bonity categories. The presented methodology of geoecological evaluation, i.e. overlapping the network of unit areas and grading by relief categories within unit areas, numerical indicators for each unit area were obtained and further classified regarding the surface coverage.

Tab. 1: Points by categories of absolute heights, slopes, vertical relief dissection and slope mobility for the needs of geoecological relief assessment.

Category	Altitude (m)	Points	Slope (^{0})	Points	Energy of relief (m/km^2)	Points	Mobility	Points
1.	Hypsometric class 1	25	0-2	25	0-5	25	stable	25
2.	Hypsometric class 2	20,8	2-5	20,8	5-30	20,8	slope washing	20,8
3.	Hypsometric class 3	16,6	5-12	16,6	30-100	16,6	slope washing and sliding	16,6
4.	Hypsometric class 4	12,4	12-32	12,4	100-300	12,4	strong erosion	12,4
5.	Hypsometric class 5	8,1	32-55	8,1	300-800	8,1	material removal	8,1
6.	Hypsometric class 6	4,1	>55	4,1	>800	4,1	landslides	4,1

Vegetation cover was evaluated on the basis of the CLC from 2018, within which three (height) categories of vegetation cover were evaluated: forests, bushes and grass vegetation. The evaluation is based on the representation / share of certain categories of vegetation, with unit areas with a higher share of forest vegetation having a higher geoecological value than those with shrubs or without vegetation. Accordingly, the unit areas that are in the highest score class with regard to relief features and are characterized by the highest share of forest vegetation have the highest geoecological value (Hrelja 2017).

Tab. 2: Geoecological evaluation of space.

Relief characteristics		Vegetation characteristics	The value of space
Category	Number of points		
6-9	70-100	with vegetation	most valuable
6-9	70-100	without vegetation	very valuable
3-6	40-70	with vegetation	relatively less valuable
3-6	40-70	without vegetation	mostly less valuable
1-3	10-40	with vegetation	mostly unsuitable
1-3	10-40	without vegetation	unsuitable

Source: Saleto Janković, 1995; Hrelja, 2017 (adapted and edited by the authors).

It is obvious that the areas at the lowest hypsometric level, with the lowest slope inclinations, relief dissection and terrain mobility, and high share of forest cover are the most valuable i.e. have the greatest socio-economic potential, while terrains at the highest hypsometric levels, with highest slope inclination and relief dissection, as well as highest terrain mobility, and in addition without vegetation, have the smallest for socio-economic evaluation.

With the presented methodology of geoecological evaluation, numerical indicators for each unit area were obtained, which is the basis for exact quantification and cartographic presentation. Such way of geoecological evaluation is especially relevant for national parks and nature parks (Hrelja 2017).

4. Research results

Based on the performed geoecological evaluation and additional analysis, it was determined that 70.4% of the total area of Nature Park Hutovo Blato is covered with natural vegetation, while 29.6% of the area is without natural vegetation cover. This ratio of areas with and without vegetation (which is reduced by anthropogenic activity) confirms the fact about the endangerment of the analyzed area, and inadequate spatial planning and management. The most valuable areas from the geomorphological aspect, due to the reduction of vegetation by 50.06%, have been transformed into very valuable terrains. Based on the evaluation of geomorphological (altitude, vertical disintegration, terrain slope and slope mobility) and vegetation characteristics of the area, in the total area, the largest share belongs to relatively less valuable terrain 44.05%. In second and third place with almost the same share are very valuable (26.32%) and the most valuable (26.31%). Significant geoecological value of the analyzed area is confirmed by a very small share of mostly less valuable (3.25%), mostly unsuitable (0.07%) and unsuitable terrains (0.03%).

Areas of lower altitudes, less vertical dissection, lower terrain slopes, less slope mobility, which are also outside the anthropogenic influences, which are covered with natural vegetation cover and have greater geoecological value.

Very valuable areas are terrains that have the lowest altitudes, the lowest slopes and the lowest vertical relief dissection. An example is the valley of the river Kupa with an altitude of 4.2 m, with terrain slopes of 0-20 and flat relief - vertical dissection of 0-5 m/km2. Other parts of the lake and river alluvial plains belong to the same category of values, which due to favorable geomorphological and other physical-geographical conditions have been left without natural vegetation cover, i.e. they have mostly been

turned into agricultural areas. The most valuable terrains in Hutovo blato that have the most favorable geomorphological characteristics and which are also covered with natural vegetation cover are very few. Examples of such areas are Kravarice (89 m asl), the slope of the terrain is 0-20 and the vertical relief dissection is 0-5 m / km2 in the northwestern part of the Park.

Thus, Milkova draga (180 m asl) in the southern and Mali Zejmir in the northern (284 m asl) part of the Park that have terrain slope of 2-50 and a relief energy of 5-30 m/km2, after grading, belong to 6-9 categories of relief, covered with natural vegetation, which corresponds to the category of the most valuable terrains. Boljuni (226 m asl) and Bovan (225 m asl) belong to the same category of values in the east, the area from Jelim across Vučja glava and Carev dol, where the altitude is up to 150 m, terrain slope 5-120 and vertical dissection 50 to 30 m/km2, in the northeastern part of the Park part of the Park. Relatively less valuable terrains include areas with higher altitudes, steeper slopes and relief energy than previously defined categories. Examples are Zvjezdana (400 m asl) and Rogovi (526 m asl) in the south, Žujina gradina (478 m asl) in the east and Crno brdo (416 m asl) in the northern part of the Park which have significant terrain slopes 12-320 and vertical relief dissection 30-100 m/km2, which as a result of difficult access remained under natural vegetation cover.

The most valuable terrains include areas that have remained outside the anthropogenic influence due to slightly higher altitudes, slightly more vertical relief dissection (mostly below 30 m / km2) and slightly higher slopes (mostly below 120). Such areas are connected to the sloping parts along the pre-lake and river alluvial plains and leveled parts of the relief at higher altitudes.

Mostly and the most unsuitable terrains are the highest parts of the Park (part of Mosor and the top of Budisavina (584 m asl) with vertical relief dissection of more than 100 m/km2, very steep slopes 32-550 on which slope wash is expressed the slopes are mostly without vegetation (Hrelja 2017).

Also, the analysis of the participation of defined categories of geoecological value in areas covered with natural vegetation and the participation of categories of geoecological value in areas without natural vegetation cover was conducted. The largest share in terrains covered with vegetation belongs to relatively less valuable (62.6.2%), the most valuable 37.3%, and only 0.1% to mostly unsuitable terrains (Fig.3.).

Areas that are not under vegetation are very valuable with a total share of 88.9% (mainly agricultural areas, pre-lake and river alluvial plains). Second place belongs mostly to less valuable terrains (11%), while in third place are unsuitable terrains with a very small share of 0.1% (Hrelja 2017).

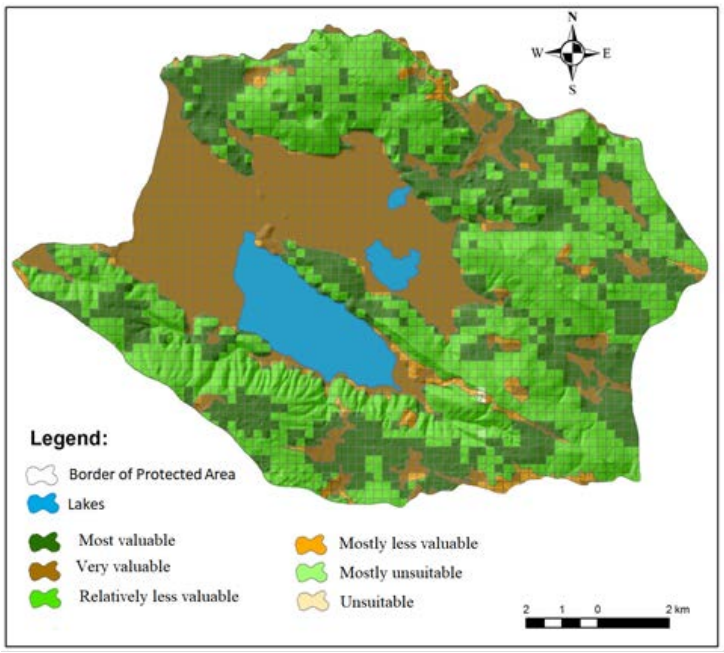

Fig. 3. Geoecological evaluation of Nature Park Hutovo blato.

5. Conclusion

Based on the conducted research, it can be concluded that geoecological evaluation is an important methodological procedure, based on which the results of the basic geoecological value of the terrain of the Nature Park Hutovo Blato were obtained. This methodological procedure includes various geomorphological analyzes and analyzes of land cover. In the first phase, component research of vegetation (coverage by different types of vegetation cover) and geomorphological characteristics of the terrain (morphological analysis of individual relief elements, such as hypsometric characteristics, energy of the relief, and terrain mobility) was conducted. However, only with the implementation of such individual analyzes for individual elements of the relief and vegetation cover, the results of the total value of the terrain of the analyzed area cannot be obtained.

Geoecological analysis of the terrain was carried out on the basis of a complex analysis, by overlapping previously prepared thematic maps. This procedure singles out areas that are unsuitable, mostly unsuitable, mostly less valuable, relatively less valuable, very valuable and most valuable areas, based on whose analysis assumptions for further economic development of the study area can be given. The obtained results are very important, primarily because their application in the process of special purpose spatial planning can significantly improve, rehabilitate and adapt certain constitutive elements of space, as well as the overall economic, tourist and geoecological value of the protected natural area.

It is important to emphasize that the previously conducted methodological procedure - terrain evaluation based on the analysis of relief and vegetation, is just one in a series of necessary analyzes of physical-geographical factors that affect the process of spatial planning. Therefore, in order to plan and manage space, it is necessary to conduct a series of comparative multicriteria analyzes of physical-geographical and socio-geographical factors and make final conclusions about the purpose and use of space.

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Summary

The aim of the research is to determine how valuable certain parts of the terrain of the Nature Park Hutovo Blato are for the needs of spatial planning, and for the purpose of use for tourist valorization, construction of facilities, agricultural activities, inter alia. Apart from the purpose of economic exploitation, geoecological evaluation is also carried out with the aim of protecting the environment. Nature Park Hutovo Blato is located in the southern part of Bosnia and Herzegovina, east of the lower Neretva, in the Čapljina-Hutovo crypto-depression. Due to its favorable natural and geographical characteristics, it has good preconditions for the development of biodiversity and geodiversity, but also for anthropogenic use of space. The methodology of geoecological evaluation of the terrain through the analysis of five spatial elements: absolute heights, slopes, slope mobility, vertical relief dissectionand vegetation characteristics was used. In the evaluation procedure, a spatial matrix structured from a network of unit areas of 250 m2 (ie 1 x 1 cm on a 1:25 000 map) was used. Its overlap with analytical maps (of listed spatial elements), and scoring within unit areas (according to the established value scale), resulted in the geoecological value of the spatial elements within the protected natural area.

Based on the conducted evaluation, it was determined that in the total area, the largest share (44.05%) belongs to relatively less valuable terrains. In second and third place with almost the same share are very valuable (26.32%) and the most valuable terrains (26.31%). Significant geoecological value of the research area is confirmed by a very small share of mostly less valuable (3.25%), mostly unsuitable (0.07%) and unsuitable terrains (0.03%). Areas of lower altitudes, less vertical relief dissection, lower terrain slopes, less slope mobility, which are also outside the anthropogenic influences and which are covered with natural vegetation cover, have greater geoecological value.