

Landscape planning as a tool for preserving the landscape values of the Dinara Nature Park

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Dinara Mountain massif is recognized as an area of exceptional value, which led to its recent protection as a nature park, the second largest one in Croatia. The protected area includes the territory of two counties with four cities and nine municipalities, five of which are included with over 50% of the territory. The paper explains how landscape planning methods establish potential spatial conflicts and propose a compromise between landscape conservation and spatial development. The basic method was the identification and analysis of the landscape value models in 3 categories: natural, visual-experiential, and cultural-historical values. The creation of the models is preceded by a detailed analysis of all environmental components and the collection and creation of spatial data with the help of GIS tools. By overlapping the basic models, a cumulative model of the overall landscape values of the space is produced, which clearly shows which parts of the landscape have a higher value, regarding the protection requirements. The final value model is overlapped with the planned interventions and a clear overview of the vulnerability and possible conflict zones in the area is obtained. The paper describes the impact of individual interventions on the landscape qualities that need to be preserved and suggests guidelines for spatial plan corrections for the purpose of minimal impact on existing values, thus helping to prevent unwanted changes.

Keywords: Dinara Nature Park, landscape planning, landscape evaluation, GIS, sustainable development

1 Introduction

A landscape is created by the interweaving of diverse material and immaterial spatial elements, the combinations of which result in the diversity and specificity of the character of an area (Landscape Institute, 2002). Landscape planning analyses and evaluates all these components of the landscape in different ways, in order to recognize and preserve endangered qualities. Using various methods with an emphasis on GIS tools, it coordinates development activities and environmental protection in the same area (Tomić Reljić et al., 2017). Since the same landscape can be the basis for different land uses (Steiner, 2008), planning distinguishes which uses are most suitable, while at the same time enabling development and protection, and leaving the smallest possible impact on the space. As Nijhuis et al. (2011) conclude, in this way landscape planning helps to

preserve social relations, a sense of belonging and rich cultural mental links woven into the environment. Every development activity in the area has a direct or indirect impact on the landscape and its qualities. For this reason, it is important to recognize existing qualities to predict the best possible vision of landscape development, with the least possible impact of that quality (Kienast et al., 2007). We recognize such a principle as 'As Least As Reasonably Achievable' (ALARA), an ethical principle according to Taylor (1986), which dictates that the development of space must strive to achieve the minimum possible impact on human and natural components of the environment (Tomić Reljić & Butula, 2011). The area of the Dinara Mountain massif is recognized as an area of exceptional geological, biological, landscape, cultural and historical value, which is why in 2021 its 630.50 km² was declared the Dinara Nature Park, the second largest nature park in Croatia. The park covers the territory

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of two counties with four cities and five municipalities, five of which with more than 50% of the area are within the protected area. Based on their development requirements, which include large infrastructure projects in the mentioned area, there is a possibility of conflict between the development efforts of the community and restrictions within the protected area whose primary goal is to preserve the existing qualities.

The goal of the paper is to determine the obstacles and opportunities for the development of the area, considering the values of the landscape, for which the area is protected. The basic method of paper is the modelling of landscape values in several categories: natural, visual-experiential, and cultural-historical values, and finally the derivation of the overall landscape values of the Dinara Nature Park.

After that, the paper analyses the relationship of the final value model with interventions foreseen in spatial plans and indicates potential spatial problems of development plans.

2 Material and methods

2.1 Description of the area

Dinara Nature Park is located in the interior of Southern Dalmatia (Figure 1), bounded by the border of Bosnia and Herzegovina to the north and Lake Peruča and the river Cetina to the south. The area is divided by two counties: Šibenik-Knin with 8.89% of the territory within protection and Split-Dalmatia with 7.85% of the area within protection. The area includes the entire Dinaric massif, which includes the mountains Dinara, Troglav and Kamešnica in a length of 84 km, the direction of which is parallel to the coast in the direction northeast – southwest.

Dinara represents the *locus typicus* of highly developed Dinaric karst. Due to its composition, karst manifests itself through a variety of geomorphological forms such as ravines, sinkholes, fields in karst, karst plains and canyons, but also through specific karst hydrology, scarce on the surface and rich underground. The high mountains are mostly bare, with numerous almost vertical cliffs, mountain ridges and peaks, rocks and speleological objects. In the area of the massif, there is the highest peak in Croatia – Sinjal with 1,831 m above sea level. The southern part of the area is characterized by a lowland landscape where fertile soils of karst fields develop due to washing, erosion and accumulation of material from the slopes and flooding of water bodies and smaller karst fields along the course of the Cetina River. Next to the karst fields, numerous plains develop and there is a high concentration of dips, and sunken relief forms in the terrain that are created by the accumulation of slope material on which fertile soil develops.

An area is known as a highly natural and biodiverse, with diverse habitats and numerous endemic species. The most important are different types of natural and semi-natural grasslands, which make up over 50% of the surface, and which are more significant due to their natural and cultural significance. They have been used for centuries for livestock grazing, but although they still make up the largest part of the habitat of the Nature Park, with the abandonment of livestock farming, they are subject to succession and the loss of significant species (Institute for Environmental and Nature Protection (IENP), 2020). Almost the entire area is protected by the Natura 2000 ecological network. Numerous archaeological remains indicate that this area has been inhabited since prehistoric

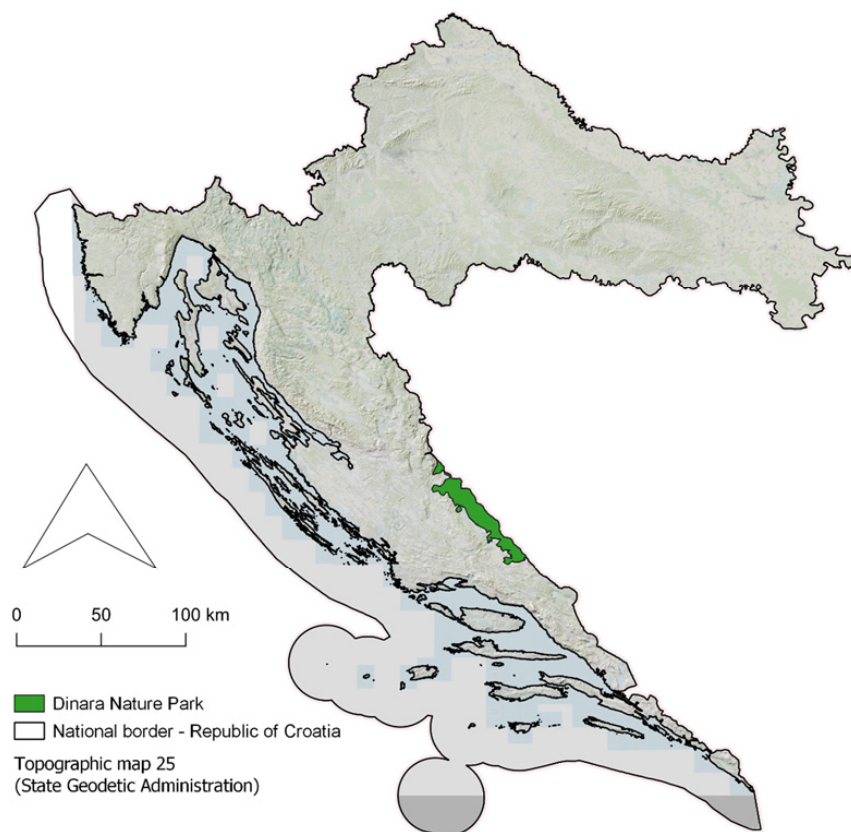


Figure 1 Location of Dinara Nature Park

times, and Dinara is nationally significant as there are rich remains of Croatian history from the 10th century in its surroundings. Today, the area is marked by a trend of strong depopulation. The flooding of the Cetina River and the construction of the hydroelectric power plant on Lake Peruča in the middle of the 20th century significantly changed the economy and landscape of the area. Numerous settlements and lands were submerged, which led to the emigration of the population, and the peak of emigration followed the Homeland War in the 1990s. The centuries-old tradition of extensive livestock farming has survived to this day, although at a much lower intensity and in a modern way. Inextricably linked to grazing is the traditional dry-wall construction characteristic of the whole of Dalmatia – dwellings for people, and livestock, and kilometres of dry-wall borders and roads. The bad demographic and economic picture influenced the reduction of grazing, which shaped the cultural landscape of the Dinaric area. Grassland overgrowth threatens the survival of species that are important for the area's biodiversity, while traditional construction is subject to destruction and neglect, which also destroys the rich heritage. However, some traditional stone mills, stone bridges, historic churches, fortresses and cores of historic settlements are protected.

2.2 Landscape evaluation

At first, it was necessary to collect and create a spatial database using the GIS (QuantumGIS 3.14), where all the components of the environment are given their exact coordinates in the Gauss-Krüger projection, in the raster format of polygons, or in the vector format of points or lines through the georeferencing process (Figure 2). All georeferenced components of the environment are evaluated in 3 different categories: natural, visual-experiential and cultural-historical values of the landscape. By overlapping all 3 models, a final model of the overall landscape values of the Dinara Nature Park is formed. The values assigned to each environmental component are:

- 0 – not valuable,
- 1 – least valuable,
- 2 – less valuable,
- 3 – medium value,
- 4 – valuable,
- 5 – very valuable.

Spatial data is converted in the GIS application ProVal2000 into a raster network (pixels 10 × 10 m size), whereby the rating of some environmental component is added to each pixel that makes up that spatial data. Several environmental components can overlap on each pixel, which is why different values are assigned to it.

The 'multi sum' function adds all the values within the same pixel and calculates its average values. To highlight very important values, the 'multi max' function is used, which recognizes the highest value on a pixel and determines it as the final one.

When evaluating the visual-experiential qualities, separate visual analyses are done with GIS tools: analysis of visual units, analysis of visibility from certain points, and analysis of the overall visibility of the terrain. A visual unit is a smaller area of a larger landscape with specific visual characteristics that distinguish it from another. According to Tomić Reljić et al. (2022), an unit is distinguished by determining the visual edges of the area, which often form relief features. Each unit is evaluated through the same five categories that are assigned a rating from 1 (low) to 5 (high), and the arithmetic mean of the ratings of those criteria constitutes the overall rating of the visual unit. Evaluation criteria of visual units taken from Tomić Reljić et al. (2022) are as follows: representativeness, visual integrity, coherence, complexity, and overall impression. The 'Viewshed' tool is used to analyse visibility from certain points in space which indicates from how many points is each pixel of the terrain visible, considering terrain obstacles (Čučković, 2020a). The analysis of overall visibility was made with the 'Visibility index (total viewshed)' tool, which shows the visibility for each pixel of the terrain, with two possible options – from each pixel or to each pixel (Čučković, 2020b).

After creating the final value model of the landscape, the spatial planning documentation of Split-Dalmatia and Šibenik-Knin Counties and their cities and municipalities is analysed. The paper identified 58 planned interventions in the area of the Nature Park, which are georeferenced and overlapped with the value model of the landscape, which makes it possible to observe over which values planned activities are being placed. The GIS tool 'Raster analysis' – 'Zonal statistics' calculates the average vulnerability rating of the entire area on which the intervention is located, thus determining the vulnerability of the landscape according to the following evaluation:

- 1 – not vulnerable and without negative impact,
- 2 – slightly vulnerable with negligible negative impact,
- 3 – vulnerable, negative impact exists but is acceptable,
- 4 – very vulnerable with high negative impact,
- 5 – most vulnerable with unacceptable negative impact.

At the end, the impact of the intervention on the quality of the landscape is described and guidelines are proposed for the correction of plans and interventions.

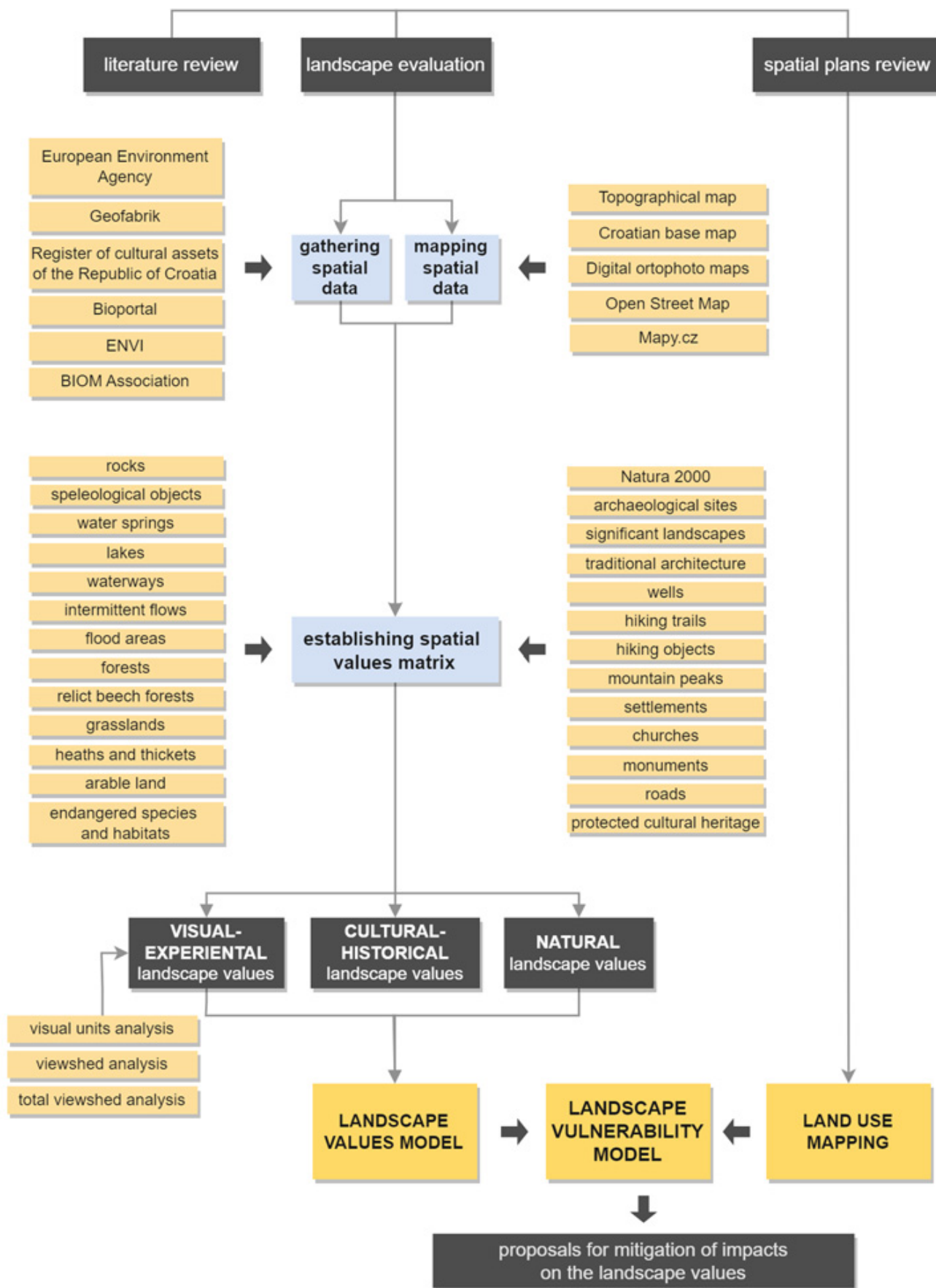


Figure 2 Overview of the landscape evaluation process

3 Results and discussion

3.1 Natural landscape values

The natural values of the landscape are evaluated from the point of view of biodiversity, rarity, and significance for the functioning of the entire ecosystem. Habitat types that are extremely important for the preservation of natural values are grasslands, water courses, springs, and water bodies. In addition to them, the beech forests were separated because they are the only remnants of the original beech forests that dominated the area. In addition, various species and habitats are endangered, under protection at the national level or covered by Natura 2000, and are highly valued so their conservation is taken into account. Areas that were classified as significant landscapes before being declared a Nature Park,

but which have now been cancelled, are also highly valued. Nevertheless, these localities are of exceptional natural importance because they are the sources of karst rivers that are significant for the natural diversity of this area.

By overlapping the values of all environmental components important for the naturalness of the area, a final model of natural values is formed (Figure 3). According to this criterion, about 27% of the area is of medium to highest value, and they are concentrated around the Dinara mountains, and along the areas of mountain grasslands that stretch along the border with Bosnia and Herzegovina. Areas of the greatest natural value are also located in the lowlands, along with the water areas of the Krčić and Cetina rivers and their sources and floodplains.

3.2 Visual-experiential landscape values

The Dinaric area is known as an important perceptive area because the karst pasture landscape prevails and it is the highest mountain in Croatia, therefore it is evaluated from a visual-experience criterion. Environmental components of high value for this criterion are rocks and mountain grasslands as well as watercourses, lakes and springs. In addition, the traditional construction of wells and houses, as well as the mountain tops with wide and deep views, are attractive. Hiking facilities, trails, and forest habitats are also attractive. Archaeological sites, caves, and occasionally flooded areas, which are often inaccessible and not perceived in space, are of lower experiential value. When creating the model of –visual-experiential values, visual units (Figure 4A), terrain visibility from certain points (Figure 4B), and overall terrain visibility (Figure 4C) were analysed. Due to the different forms of spatial recording of these analyses in GIS programs, only the value of visual units is added to the final model, while other analyses can descriptively indicate areas of greater importance. There are 17 visual units in the area, of which 11 are highly rated with 4 or 5. These are mainly cliffs, extensive high-mountain pasture areas, and lowlands and hills that are visible from heights, and also contain visually prominent anthropogenic structures of traditional construction.

For the analysis of visibility from certain points in space, mountain peaks and facilities are used as viewpoints, which most often offer expansive views and around which there is a greater concentration of passers-by. The result shows the areas of the highest visibility from the largest number of views, which indicates the areas that are most visible in space, namely the higher mountain grassland areas

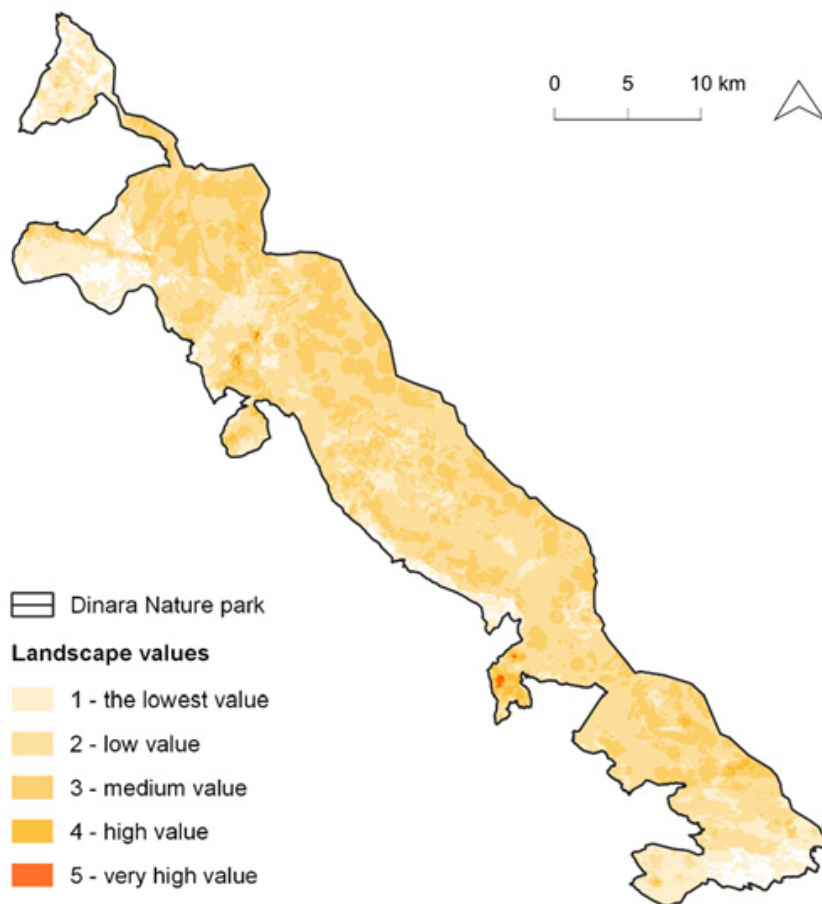


Figure 3 Natural landscape values of the Dinara Nature Park

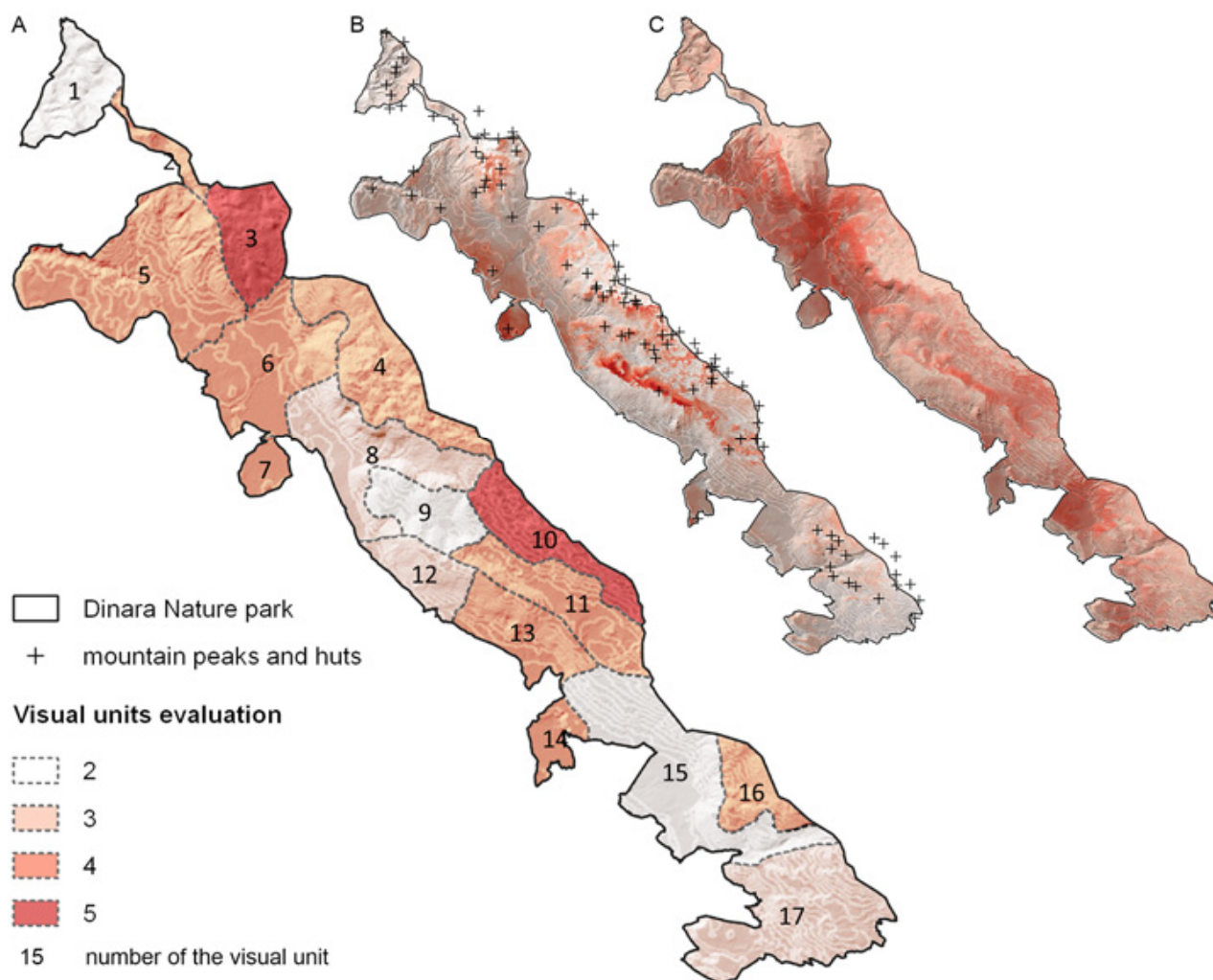


Figure 4 Visual analyses of the Dinara Nature Park
 A – visual units' analysis, B – viewshed analysis, C – total viewshed/visual index analysis

and the ridges around them, and the slightly less open karst fields at the foot of the mountains. By analysing the overall visibility of the terrain, the overview of the terrain is analysed at all points (pixels) in space, and we get a view of the overall visibility of the entire terrain. The final analysis indicates that the most visible area is around the high cliffs of the highest mountain peaks, but also the vast foothills of those cliffs that can be seen from the mentioned ridges.

By overlapping the values of the components and visual analyses, the final visual-experiential model was obtained (Figure 5). About 25% of the area has medium to highest values, consisting of higher mountain areas with numerous high grasslands, a landscape of dips and rocks, and often present traditional construction. They are characterized by the openness and spaciousness of the area due to the low surface cover and variety of relief forms. Numerous hiking facilities and trails are also

located there, which are also highly valued according to this criterion. In addition to mountainous areas, high visual and experiential values can also be observed in the lowland areas around the floodplains of the Krčić and Cetina rivers and their sources. Visually prominent, open and spacious cultivated fields are often located around these areas, which offer deep views of the entire mountain massif and cliffs.

3.3 Cultural-historical landscape values

As this area has a long history of settlement and cultural development, it is essential to evaluate the landscape through a cultural-historical aspect. The highest values were attributed to archaeological sites, churches, monuments, and protected material cultural assets. In addition, the highest marks were attributed to the traditional construction, which is rich in this area, and which is often in decay, abandonment and overgrowth.

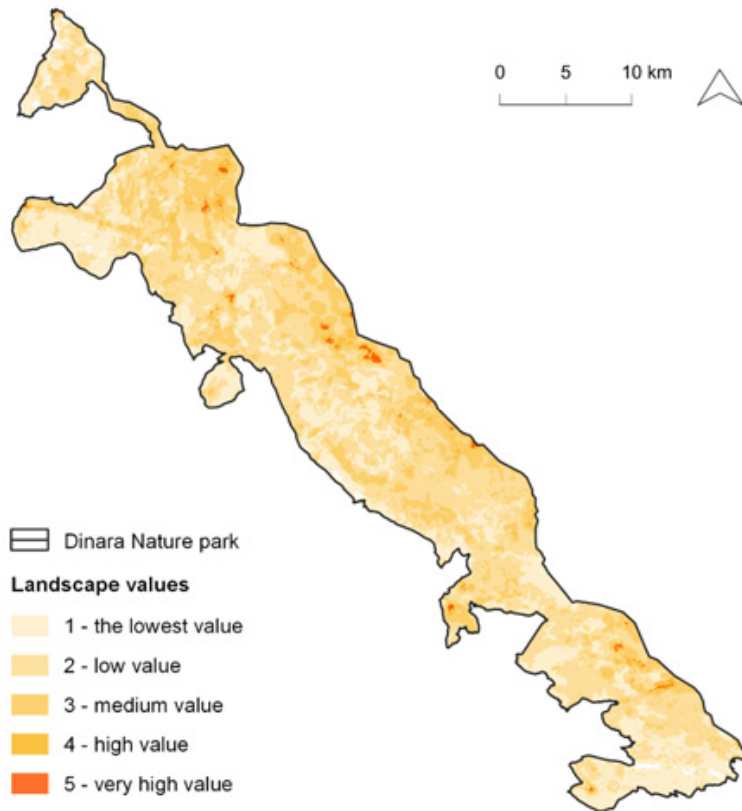


Figure 5 Visual-experiential landscape values of the Dinara Nature park

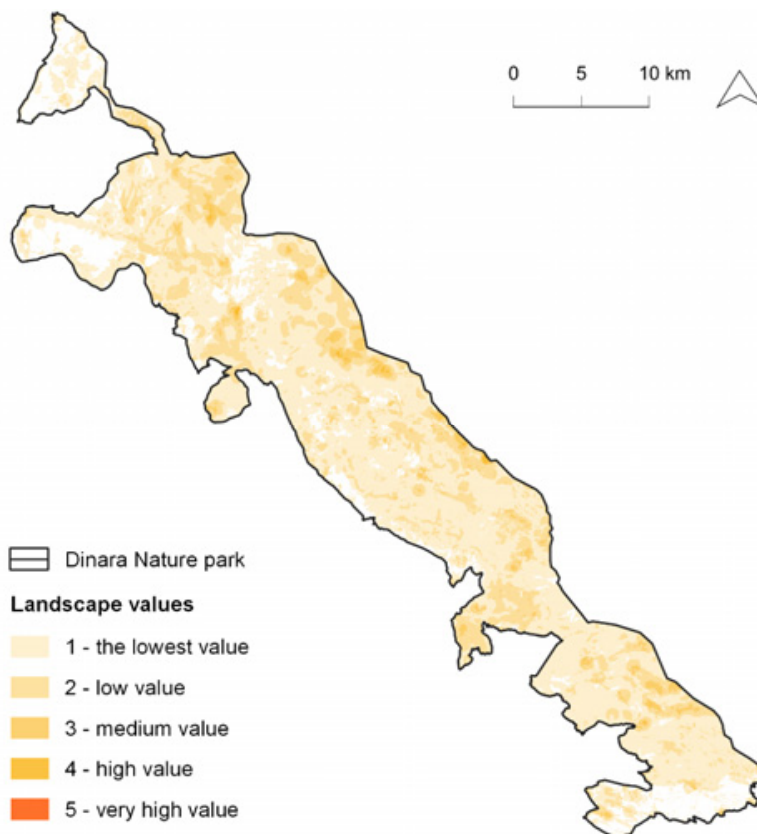


Figure 6 Cultural-historical landscape values of the Dinara Nature Park

Grasslands are the most culturally valuable habitat type in this area, given the long tradition of cattle breeding and society's dependence on this activity. Due to its mountainous character, visibility of the area and natural-geomorphological wealth, Dinara is a destination for many hikers, and thus mountain peaks, trails and huts are highly valued as culturally important spatial elements.

Considering the large area and the scattering of smaller cultural-historical elements, the final model of cultural-historical values indicates a small part of the area of medium to highest value (Figure 6). The highest values are dotted in the higher mountain zones where there are large pasture areas and numerous localities of traditional construction, considering the semi-nomadic herding way of life in the mountains that shaped the culture and specificity of this place.

3.4 Final model of landscape values

The overall landscape value model of the Dinara Nature Park is created by overlapping three sub-models: natural, visual-experiential, and cultural-historical value model, and with this work the final values are modelled in two different ways. As the 'multi sum' function of the ProVAL2000 software calculates the average value for each pixel, the value of certain significant components of the environment is reduced in the overall sum. For this reason, a second model is created with the 'multi max' function, which recognizes more important components according to a certain criterion and sets their value as the final pixel value. Thus, the larger values of the landscape are minimally emphasized, which nevertheless makes a significant difference in the context of the work, because a large area is analysed in



Figure 7 Final model of landscape values of the Dinara Nature Park

which the values of smaller areas are easily reduced in the final sum.

With the final model of the 'multi max' function, over 30% of the landscape was recognized as medium to high value (Figure 7). These are the areas of high mountains where there are the highest values with all 3 criteria: natural, visual-experiential, and cultural-historical values. These areas are dominated by the cultural landscape of pastures and traditional buildings, which were the basis for declaring the status of a Nature Park. In addition, more valuable are areas with scarce permanent, and intermittent watercourses, and floodwater bodies, and numerous springs located in lower areas, along the southern border. Water areas are valuable from the point of view of biodiversity, but they are also places where culture developed, which is why even today the area is known for its rich heritage. In addition, there are

specific characteristics of openness and transparency, as well as landscape patterns of cultivated and natural surfaces, which, in addition to the elaborate relief forms of the higher areas, are the most valuable from the experiential aspect of the space.

4 Conclusions

Through this work, analytical, precise, and measurable methods are used to visualize the pressures on the space by modelling the vulnerability of the landscape, which shows the relationship between the values of the landscape and the activities planned on them. Modelling does not solve the problem by itself, but it enables the visualization of conflicts in space and can help decision-makers to see the impact of an intervention in space so that they can make correct alternative decisions to reduce or eliminate

pressure on the human and natural environment.

The obtained value model of the value of the landscape of the Dinara Nature Park was overlapped with the planned interventions drawn up in the Spatial Plan of Šibenik-Knin County, the Spatial Plan of Split-Dalmatia County and the corresponding spatial plans of cities and municipalities, which recognized 58 planned interventions in the protected area. Each intervention is marked by a given code which is a combination of the first two letters of the city or municipality in which the intervention is planned, and the number of the intervention. For example, kn1 is code for the first intervention planned in the City of Knin spatial plan. By calculating the average vulnerability of the area that arises for each individual intervention, 12 interventions were observed, the impact of which produces a landscape vulnerability greater than 2.5 (Table 1, Figure 8). It is mostly about a medium negative impact on landscape values for the planned activities: two tourist resorts, solar power plants, two research areas for wind power plants, two farms, service facilities and access roads. The two planned operations of the tourist resort and the accumulations have a high negative impact, while the planned operation of the hydroelectric power plant has an unacceptable impact on landscape values. In the end, impact mitigation guidelines are proposed for the aforementioned planned interventions.

As it is easier to prevent impacts in space by changing the location or method of execution than to subsequently remove them or mitigate the consequences, landscape planning methods are a valuable tool applicable to various spatial actions and situations, and it is necessary to recognize them as

Table 1 Planned interventions that create medium to high landscape vulnerability

County	Area	Planned interventions	Code	Vulnerability
Šibenik-Knin County	City of Knin	accumulation 'Krčić Donji'	kn1	3.7
		hydro plant 'Krčić Donji'	kn2	4.9
		tourist resort	kn4	3.0
	Municipality of Kijevo	solar power plants	ki7	2.6
		tourist resort	ki10	2.8
		research area for wind power plants	ki11	2.6
Split-Dalmatia County	City of Vrlika	service industry	vr5	3.4
	Municipality of Hrvace	research area for wind power plants	hr3	2.5
		road	hr4	2.7
	City of Sinj	farm	si7	3.0
		farm	si10	2.6
	Municipality of Otok	tourist resort	ot2	4.1

scientifically established objective methods that can be used to make optimal decisions about the development of an area. By optimizing development efforts within protected and valuable areas, foundations are created

for the long-term better-quality development of an area, which also takes into consideration the consequences for the future image and value of a landscape.

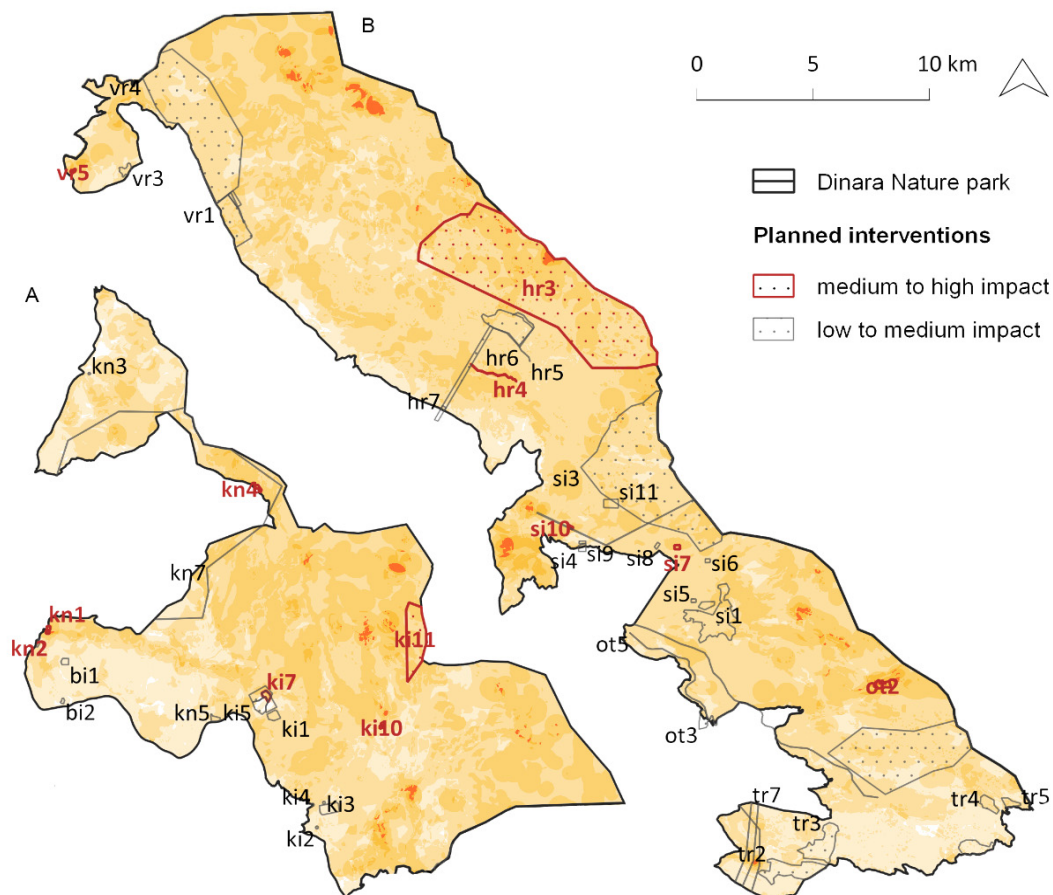


Figure 8 Final landscape values model with planned interventions
A – Šibenik-Knin County, B – Split-Dalmatia County

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