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VISIBILITY ANALYSIS AS A PART OF LANDSCAPE VISUAL QUALITY ASSESSMENT

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Abstract

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The paper presents the methodology for calculation of the potential of viewer places and potential of seen areas in the landscape that is the part of the methodology of landscape visual quality assessment. The basis of evalution within geographical information systems (GIS) was the modelling of visibility by digital model of relief (DMR) and selected features of the secondary landscape structure (SLS). The analysis was carried out in the raster data model and its result is the determination of the value of vista potential and visual dominance potential in the landscape for each grid cell. This procedure was applied in the model area of Svätý Jur and Liptovská Teplička.

Key words: landscape visual quality assessment, cumulative viewshed analysis, geographical information system (GIS), digital model of relief (DMR), Liptovská Teplička, Svätý Jur

Introduction

The paper deals with the possibilities of utilization of visibility modelling in GIS as the part of the methodology of landscape visual quality assessment. Oťaheľ (1980) deals with the evaluation of vistas from tourist paths on the scenery and in scenery perception analysis of the Vysoké Tatry Mts he used morphometric criteria, parameters of human eye optics and the theory of photography composition in order to determine the optimum vista (Oťaheľ, 1980). Oťaheľ (1999) analyzed the quality of vistas from cycle tracks according to the magnitude of visual angle and line of sight in combination with the attractiveness of landscape cover in a part of the Morava river alluvium.

Potential of visual exposure of the area in the hexagonal grid was elaborated by Štefunková (1998), who combined the potential of aesthetic quality of landscape elements with the potential of visual exposure of space for each grid cell. She established the potential of visual

exposure of the landscape on the basis of comparison of the cell position in the relief and evaluation of the structure of visual barriers in the elements of SLS. The development of the methods of visibility modelling in GIS brought wide possibilities of the analysis of visual connections in the landscape (e.g. Fisher, 1993; Lobera, 2003). Lobera (2003) deals with the use of GIS in study of human visual space. He describes different methods of analyses of visual space structure and he states that if the cognitive and perceptive factors are linked with space information, then the formation of new methods of viewshed analysis within GIS gets unavoidable. The basis of viewshed analysis is the determination of all localities (e.g. cells of raster grid) which in space can be linked with the viewpoint by straight line without any interruption. In Slovakia Hlavatá (2001) dealt with the study of potential vistas from selected observation points from the aspect of line of sight by the means of GIS. She developed certain approaches of Oťaheľ (1998) and Štefunková (1998), however she applied her own methodological procedure based upon the evaluation of digital model relief (DMR) and relief inclinations. For analyses in GIS she chose the raster grid where, similarly to Štefunková, she sets out from the presumption that each raster cell is a potential viewpoint. In sense of the mentioned methodologies she evaluated the measure of view obscuring (barriere effect) by the elements of SLS, which were evaluated also according to the height of landscape elements. In the analysis she chose the observation points on cycle tracks and tourist paths, from which she evaluated the views in 4 categories of viewing distance.

The aim of our contribution is to point at the possibilities of definition of the viewpoints potential and visually dominant places potential in the landscape on the basis of cumulative viewshed analysis by GIS. At the same time we present the mood of inclusion the so called potential of viewpoints and visually dominant places into the methodology of landscape visual quality assessment in selected model areas.

For application of the presented methods have been chosen two model areas – Svätý Jur and Liptovská Teplička. They were defined that the settlement and its vicinity form a visually and functionally connected space included also the special values of cultural and natural landscape. The model area of Svätý Jur (129–376 m a.s.l.) is situated on the border of the mountainous massive of the Malé Karpaty Mts and Podunajská nížina lowland. The town Sv. Jur, situated at the foothill of the Malé Karpaty Mts is the centre of the area and in its surroundings are vineyards, fields and forests of the Protected Landscape Area Malé Karpaty and National Nature Reserve Jurský Šúr. The model area of Liptovská Teplička (870–1302 m a.s.l.) lies under the afforested ridges of the National Park Nízke Tatry Mts. Rural settlement is situated in a small basin in the central part of the area. The surrounding landscape is created by mountain slopes and plateaus mainly extensive used as fields and meadows.

Methodology

The methodology of landscape visual quality assessment combines the evaluation of aesthetic significance of the elements of secondary landscape structure with the evaluation of vistas and visually dominant places potential in the landscape. The method is presented in Fig. 1. Within the description of application of methodological procedure of landscape visual quality assessment we focused our attention to the evaluation of visual connec-

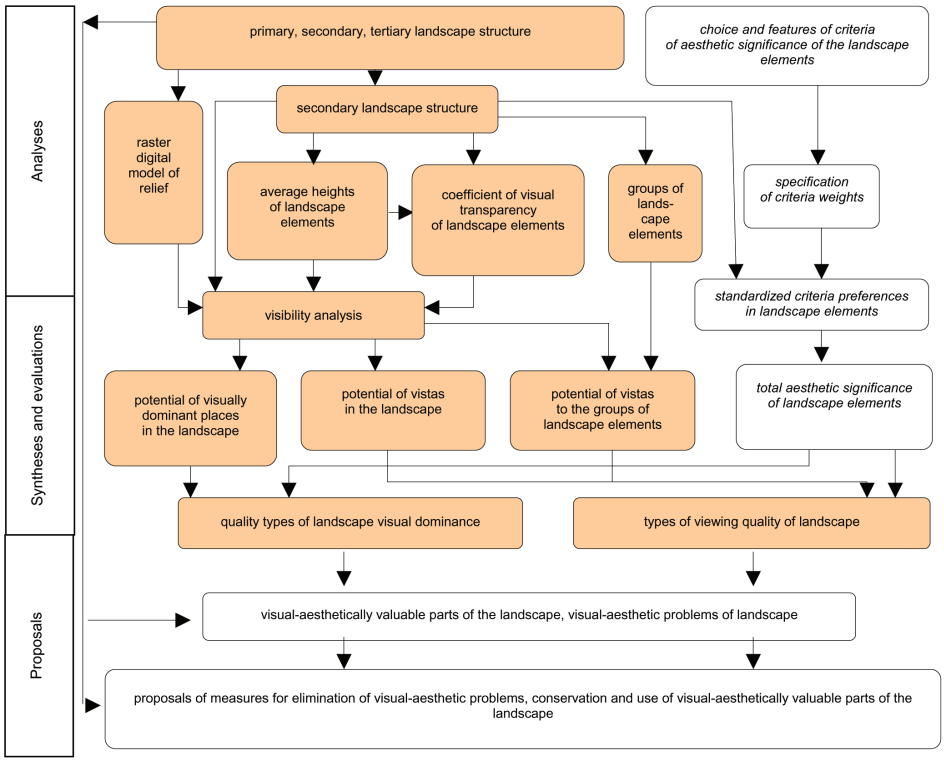

Fig. 1. Methodological approach of visibility analysis in the model of landscape visual quality assessment.

tions – potential of vistas and potential of visually dominant places. Evaluation of aesthetic significance of landscape elements is briefly characterized in the chapter Syntheses and evaluation.

Results and discussion

Analysis of landscape structure

The analysis of landscape structure was the analytical basis of the methodology application. Within the **primary landscape structure** we put emphasis on the relief analysis determining the viewing conditions in the landscape, forming visual barriers and dominants. In modelling of visibility we used the raster presentation of the digital model of relief with cell size 50 m DMR50-SK (Šúri et al., 1997). DMR was created from elevation points and contour lines of basic maps in the scale of 1:50 000.

The analysis of the **secondary landscape structure (SLS)** is the basis for cumulative viewshed analysis and evaluation of aesthetic significance of the SLS elements. The secondary landscape structure of the model areas was elaborated according to basic maps and aerial photographs in the scale of 1:10 000. The database from 1994 and 1996 was actualized according to field work carried out in 2001 and 2002. Within the frame of complementary data we analysed the **tertiary landscape structure,** including natural and cultural-historical values of the areas.

In application of the methodology the next step was to create a set of data entering into the cumulative viewshed analysis.

- **Average height of landscape elements** – elements of the secondary landscape structure (SLS) enter as visual barriers and at the same time as objects of visual perception. Average heights of types of landscape elements of the model area were defined in 10 height categories (from 0.5–30 m). The first two categories do not outgrow the height of the observer (1.75 m).
- **Coefficient of visual transparency of landscape elements** – landscape elements have different inner structure and therefore in certain cases can exist an outlook also from the places where the height of elements outgrows the height of the observer – e.g. dispersed building. For single landscape elements the coefficient of visual transparency has been defined on the basis of coverage of visual barriers in an element: 0 – not transparent, visual bariers in SLS element limit the observer›s view; 0.5 – semitransparent, visual bariers in SLS element partially limit the observer›s view; 1 – transparent, without visual bariers, the observer›s view from SLS element is not limited.
- **Groups of landscape elements** – according to prevailing landscape elements have been dissected relatively homogeneous parts from the aspect of secondary landscape structure – groups of landscape elements serving as a basis in evaluation of vistas at these groups from the model areas.

Syntheses and evaluations

In analysis of visual connections in the landscape we set out from the premise, that each discrete space in the landscape is a potential vista and simultaneously a potential seen (visible) place according to the Štefunková's methodology (1998).

Evaluation of visual connections

In the study areas the basis of visibility modelling were DMR and the properties of SLS. The modelling was realized in ArcView GIS, extension Spatial Analyst and our own moduls. Algorythm of visibility calculation has been modified that it takes into consideration the height of the observer (1.75 m). In modelling we did not establish the maximum line of sight, however the vistas exceeding the study area we have not been evaluated. For both

model areas have been evaluated the following visual conections on the basis of the created method:

a) Potential of vistas in the landscape – if we presume, that each cell of the analyzed raster is a potential vista, the value of its potential for a raster cell is given by the total number of cells visible from it. After value calculation of the vistas potential we can determine the parts of the area have the most vistas. For comparability of the results of both model areas the result values of vista potentials have been divided with the total number of cells in single areas.

The results of this methodological step application show that the vistas in Sv. Jur are concentrated to the large-block vineyards, mainly on the slopes oriented to the central part of the area. In Liptovská Teplička the vistas are significantly concentrated on mountain ridges and adjacent slopes with a mosaic of fields and meadows, reclaimed grasslands and pastures and large-block fields in eastwards and westwards of the settlement.

b) Potential of vistas to single groups of landscape elements – the value of vistas potential from the raster cell to the group of landscape elements is given by the number of cells of group visible from the analyzed cell divided with the total number of cells in the area. In such a way it is possible to establish the direction and intensity of vistas from the given look-out or from the whole area to each group of landscape elements.

In the area of Svätý Jur the forests of National Nature Reserve Jurský Šúr (Fig. 2) is the potentially most visual perceived group of landscape elements. Vistas towards the group are mostly concentrated in the large-block vineyards. Most vistas from the dissected area of Liptovská Teplička heads towards the mosaic of primary fields and grass stands (Fig. 3). On the contrary in both areas was observed a low concentration of vistas towards the historical built up areas. The potential of vistas at selected groups of both areas is demonstrated by Fig. 2 and 3.

c) Potential of visually dominant places in the landscape – in the potential of visually dominant places in the landscape is assumed that each raster cell is a potentially seen (visible) part of the landscape of model area. The value of visual dominance of the raster cell is the number of cells from which is this cell visible divided by the total number of cells.

In the model area of Sv. Jur the local elevations and parts of vineyard slopes and forest edges are turned towards the town, i.e. the central part of the area are the visually most dominant (visible) places. Also the large-block fields southwards of the town and the neighbouring forest edges of Jurský Šúr are more markedly visible. In Liptovská Teplička the visually dominant places are significantly concentrated on deforested, agriculturally used mountain ridges mainly in the eastern part and on afforested ridges of the southern part of the area.

- **Comparison of visual connections in both areas** – the methodology of evaluation of visual connections presumes that each evaluated raster cell of the model area is a vista and a visible place, too. It follows that the sum of vistas from the cell and the sum of sights on the cell is the same, the difference is in the distribution of the most intensive vistas and most intensively perceived cells in the model area.

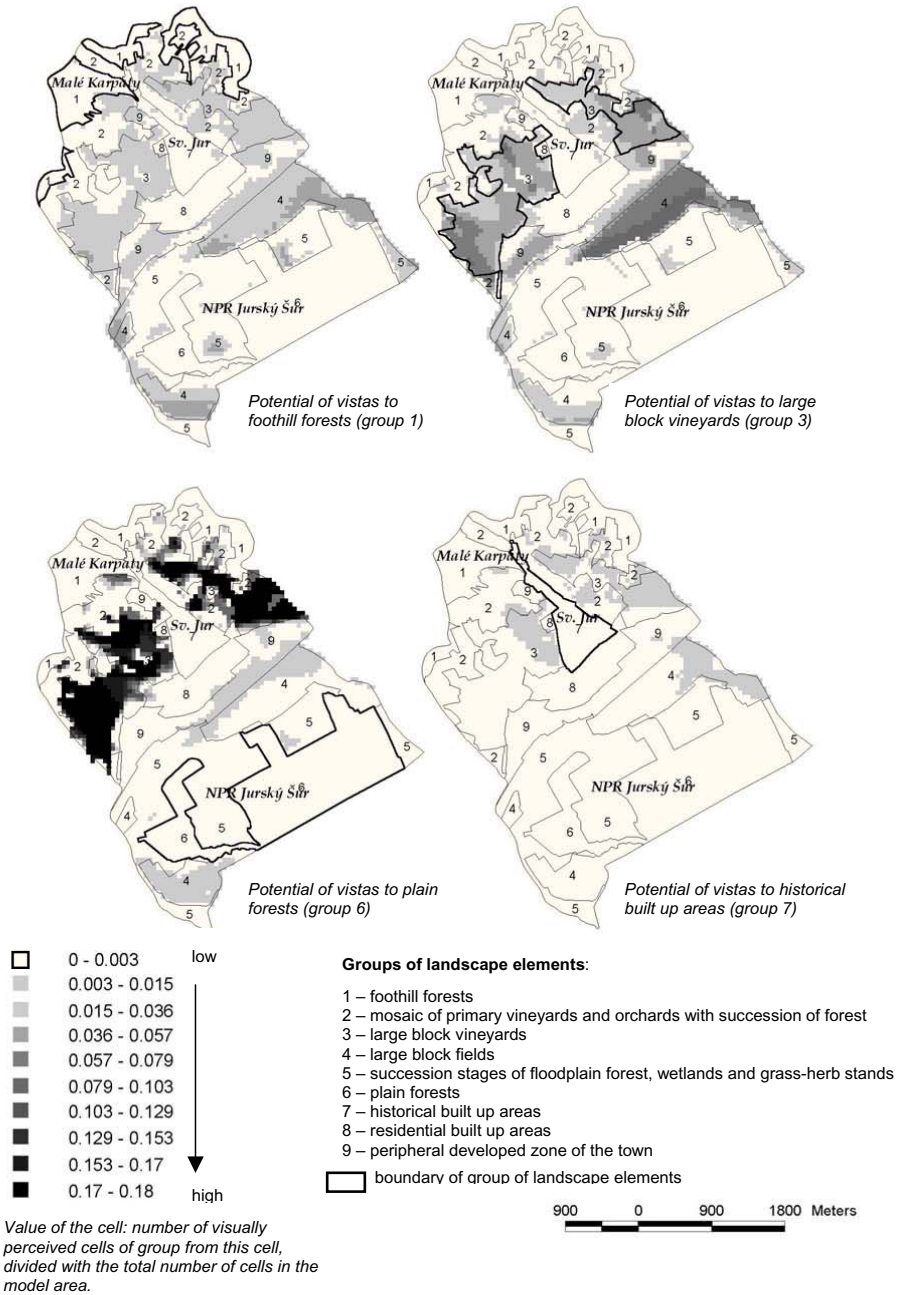

Fig. 2. Potential of vistas towards selected groups of landscape elements in the model area of Svätý Jur.

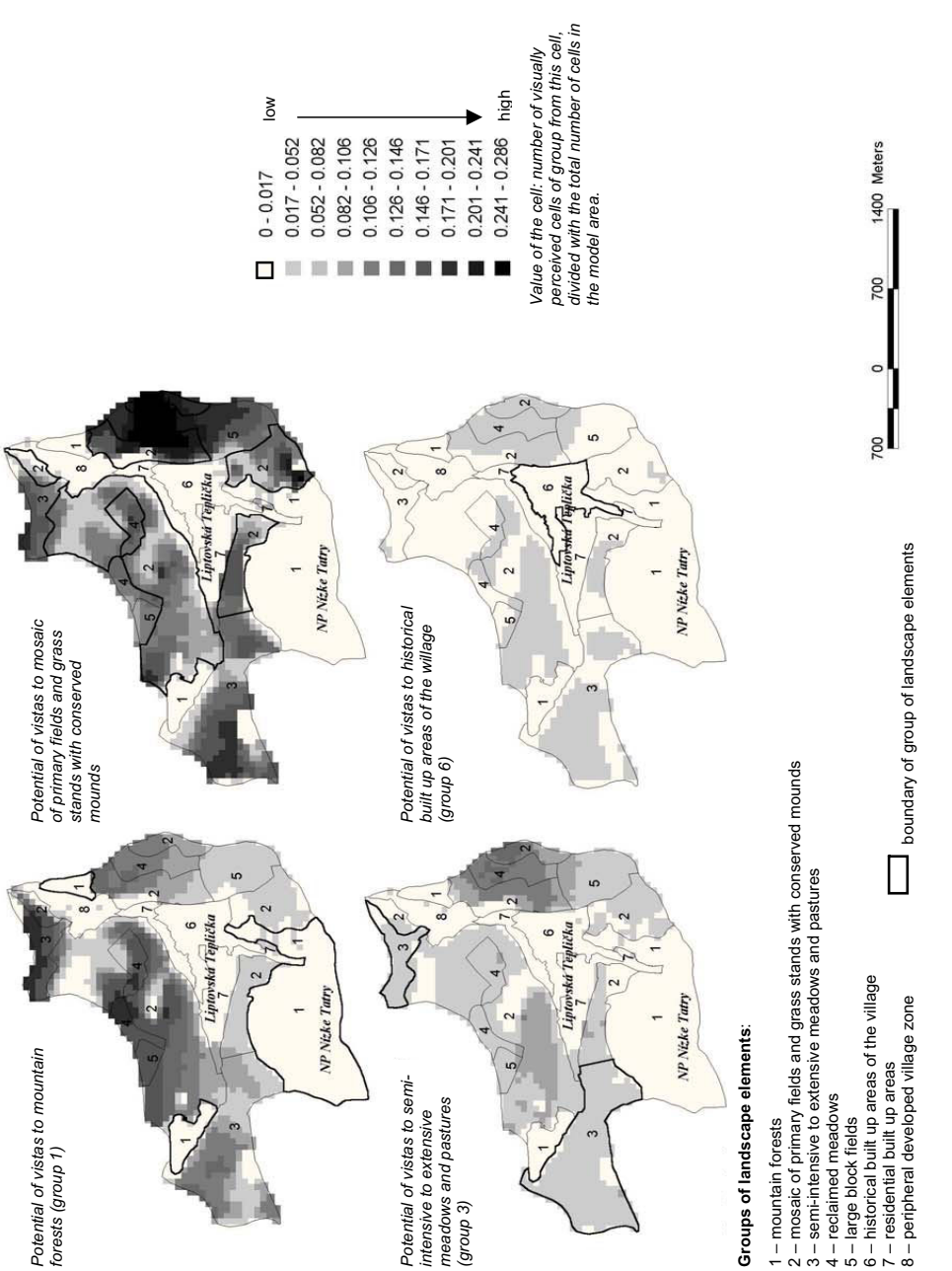

Fig. 3. Potential of vistas towards selected groups of landscape elements in the model area of Liptovská Teplička.

It is possible to compare the average number of visual connections from one cell of the area. Table 1 shows that the average number of visual connections from one cell of the area is higher in the model area of Liptovská Teplička, although its area is more than a half smaller than the area of Svätý Jur.

Table 1.

Territory	Area [ha]	Total number of cells of the area	Σ visual connections in the area	Ø number of visual connections from one cell of the area
Svätý Jur	1314	5227	2506128	479
Liptovská Teplička	542	2166	1093498	504

The values of visual connections are influenced by the alltitude variation – in Liptovská Teplička it is 432 m and in Svätý Jur 247 m. Non-negligible is also the relief, that is in Liptovská Teplička more significant and enables smaller dispersion of visual connections behind the borders. In evaluation of vistas the share and compactibility of areas without visual barriers created by landscape elements is also important in both model territories. In Svätý Jur these areas occupy 25% and in Liptovská Teplička 74% of their territories.

Evaluation of total aesthetic significance of landscape elements

Above we dealt with the analysis of properties of visual connections as a basis of landscape visual quality assessment. The part of landscape visual quality assessment was also the identification of aesthetic significance of landscape elements realized by specialists as a multicriterial assesment. We have selected 5 criteria/indicators of landscape attractiveness – originality, uniqueness, variety, harmony and orientation. Significance (weight) of single criteria were established by Saati's method. Then we identified standardized preferencies of aesthetic criteria in each element of both model areas. Standardized preference of the criterion in a landscape element is an average simple preference multiplied with weight of criterion. The sum of standardized preferences of criteria in each SLS element gives the value of total aesthetic significance of the landscape elements.

Syntheses

Syntheses are based on data integration of visual connections in landscape and aesthetic significance of landscape elements. By integration of these data can be deduced different types of landscape visual quality and proposed the measures for their management.

- **Types of viewing quality of landscape** – present the partial synthesis of aesthetic significance of SLS element and potential of vistas in the landscape. They give the complete information of aesthetic attractiveness of each space of the model areas and at the same

time of intensity of vistas to the surrounding area, while the database includes the information to which groups of landscape elements are vistas directed (most, least). Types of

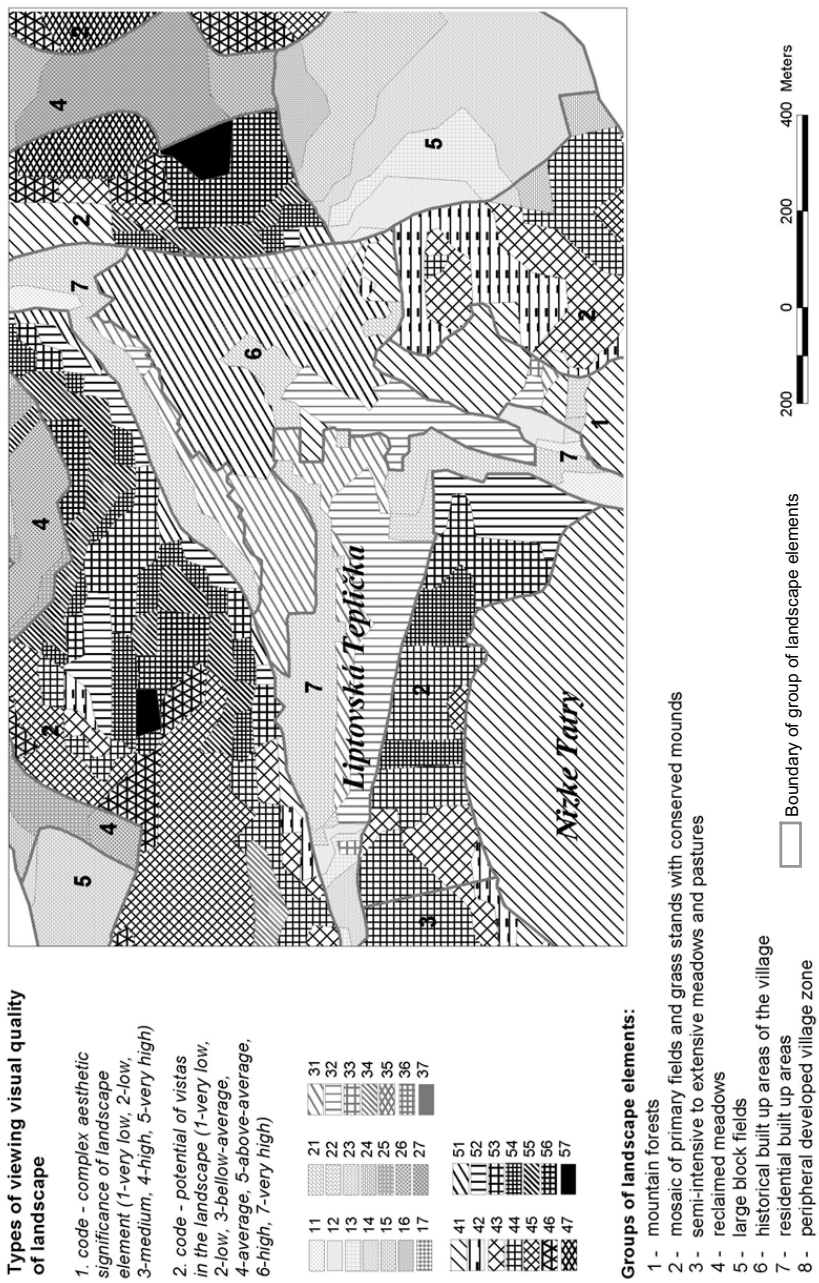

Fig. 4. Types of viewing visual quality of landscape – part of the model area of Liptovská Teplička.

viewing quality of landscape specified in Liptovská Teplička are represented in Fig. 4.

- **Quality types of landscape visual dominance** – present a partial synthesis of complete aesthetic significance of the landscape elements and potentials of visually dominant places in the landscape. They give information about aesthetic attractiveness of each discrete space (raster cells) of the model area and its visual dominance.

Conclusion

Synthetical bases about types of landscape visual quality, completed with the data of vistas on groups of landscape elements, of present use and cultural-historical and natural values of the area are the complex basis of specification of visual-aesthetic problems and visual-aesthetic valuable parts of the landscape and they serve as a proposal of their solution and management. The proposals of elimination of the visual-aesthetic landscape problems include different measures as vegetation arrangement, change in use, sanitation of degraded spaces, financial support of housing developments suitable to the given type of landscape etc. Proposals of protection and use of visual-aesthetic valuable landscape segments are aimed at the establishment of limits and regulatives in groundworks and changes in utilization of agricultural and forest areas, expansion of built-up areas, location of visually perceptible objects, building intervenes into cultural-historically important objects, materials, height of buildings etc.

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Štefunková D., Cebecauer T.: **Analýza vizuálnych prepojení v krajine ako súčasť hodnotenia vizuálnej kvality krajiny.**

V práci prezentujeme metodický postup pre výpočet potenciálu výhľadových a vizuálne dominantných miest v krajine, ktorý je súčasťou metodiky pre hodnotenie vizuálnej kvality krajiny. Základom hodnotenia v prostredí geografických informačných systémov (GIS) bolo modelovanie viditeľnosti s využitím digitálneho modelu reliéfu a vybraných vlastností súčasnej krajinnej štruktúry. Analýzu sme vykonali v rastrovom dátovom modeli a výsledkom je určenie hodnoty potenciálu výhľadového bodu a potenciálu vizuálnej dominancie v krajine pre každú bunku rastra.Tento postup sme aplikovali na modelových územiach Sv. Jura a Liptovskej Tepličky.