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MODELLING OF CHOSEN SELECTABLE FACTORS OF THE DEVELOP OF TOURISM WITH GEOGRAPHIC IT AND FUZZY SETS USING

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Abstract

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The tourism is the significant tool of prosperity not only of the well-known touristic regions, but it is significant potential developing element of not so developed provincial regions. Develop and placements of tourism are dependent on factors (conditions) that influence its use in concrete regions. These factors are classified into selectable, localisation, and realisation (localisation and realisation factors issue was published as a part of solution of the research plan of FBE No. MSM 6215648904, part 03). The selectable factors determine the possibilities of the region to develop tourism in demand function. The landscape character and the environment appertain to these objective presumptions. But these presumptions were subjective perceived. The aim of this paper is to make methodology of evaluation of introduced selectable factors. Geographic information technology will be use for spatial modelling. Theory of fuzzy sets, with its ability to catch the vagueness, will be use for defining of fuzzygeoelements and for the making several fuzzylayers. The fuzzylayers will be come into map algebra for whole formulation of these selectable factors. The methodology will be verified on territory micro region Babi lom (south of Moravia).

tourism, spatial modelling, geographic IT, fuzzy sets, map algebra

The tourism is the significant tool of prosperity not only of the well-known touristic regions, but it is significant potential developing element of not so developed provincial regions. Develop and placements of tourism are dependent on factors (conditions) that influence its use in concrete regions. These factors are classified into selectable, localisation, and realisation. Localisation and realisation factors issue was published as a part of solution of the research plan of FBE No. MSM 6215648904, part 03. The selectable factors determine the possibilities of the region to develop tourism in demand function. The landscape character and the environment appertain to these objective presumptions. But these presumptions were subjective perceived.

The aim of this paper is to make methodology of evaluation of introduced selectable factors.

MATERIAL AND METHODS

Factors affecting tourism are usually divided into three groups: localization, implementation and selective. Location of concrete forms of tourism (sport, recreation, spa …) belongs to localization factors. These localization factors are divided into conditions of the natural character (climatic, hydrological, morphological rate, flora and fauna) and conditions of the cultural and social character (historical, architectonic and technical monuments, sport and cultural events, celebrations and folk customs). (Drobná, Morávková, 2004) Implementation factors are necessary to exploit localization and selective conditions in the place. Traffic conditions, material and technical base of tourism are implementation factors. Selective factors designate the ability of a location to improve tourism in the function of demand (Machalová, Vajčnerová, Ryglová, 2010). In much literature, e. g. Holloway (2006) and Middleton (1994), are not the localization and im-

plementation factors differentiated so strictly. **Selective factors** are objectively assessed (political stability, economic, legislative and administration conditions) and subjectively assessed (environment, landscape character). Among subjective selective factors are also included these, which are differently valued by concrete people participating in tourism and are related to customer behavior.

A lot of information exists about the environment at present. However, environment indicators have not been unified. Above all, these values are quantitative for the present, less qualitative (Donnelly, 2006). Assessing condition and progress of the environment is done through indicators of the environment. There are many international institutions and organizations attending the indicators today such as OSN, OECD, World Bank, and at the level of Europe such as European Environment Agency or European the statistical office of the European Union – Eurostat. The offices monitor several groups of indicators affecting the environment, whether it is the environmental indicator or cross-sectional indicator – besides structural indicators based on Lisbon strategy also sustainable development indicators belongs to this group. Key indicators comprises 8 topics of the environment (climate, quality and air pollution, water resources management and water quality, biodiversity, forests and landscape, flow of waste and material, health, funding of the environment protection) and 3 topics of the influence of sectors over the environment (agriculture, energetics and industry, traffic). The landscape character was mentioned in 1920 in the Ration Law (No. 47/1920 Coll.) and also Consolidating Law (No. 47/1948 Coll.). Legal establishment of significant landscape elements contributing to the landscape character is in Act No. 114/92 Coll. (§ 3 and 4) as the ecological, geomorphological or esthetic value part of the landscape. Significant landscape elements are forests, peat-bogs, rivers, ponds, lakes, flood plains. Furthermore, they are also the other parts of the landscape registered by Nature's protection Authority. Significant landscape elements are part of the landscape, which protection has been given by European Landscape Convention since year 2000. Part of the evaluation of the landscape character is the specification of natural, cultural, social and esthetic values of landscape. Spatial relations in landscape are also subject of protection of landscape according to the Law above. Relationships can arise from a functional usage and operations in the landscape, from specific artistic or religion landscape concepts, from the symbolism of landscape, from specifics of settlement and landscape profiles or other context. Existing methodical approaches universally accept splitting the protection of landscape character into causal and preventive form.

- Causal protection of landscape character uses assessment of the impact of specific projects on the landscape character.
- Preventive protection of landscape character is well timed formulation of principles and methods of protection of landscape character in the form of separate protocols.

In decision making process is storage, processing, analyzing and output of information an important aspect. Significant support in decision making processes used to be information systems. In the case of decision making in a field adherent to the landscape, the **geographic information systems** are used. Tourism is inextricable connected with spatial. Geographic information systems are suitable tools for process and phenomenon modeling in the field of tourism (Machalová, 2007). Information is stored in the form of data, geo-information in the form of geodata. Spatial data or **geodata** are data related to exact places in space and for which are known exact locations of these places in the required level of resolution (Rapant, 2006). Geodata can be stored in raster or vector representation.

Map algebra is a tool able to process raster representations of reality using the language of map algebra. Operations of map algebra can be executed with one or more layers. Operations (functions) are divided into local, zonal, focal and global (Tomlin, 1990). Parts of the functions are arithmetic operators (plus, minus, times, divided), Boolean operators (true, false), relation operators (greater than etc.) and then specialized such as bit shifts, accumulative, combinatory and assignment operators. Then operands are values stored in a cell (cells) of the layers entering a spatial analysis (see Fig. 1).

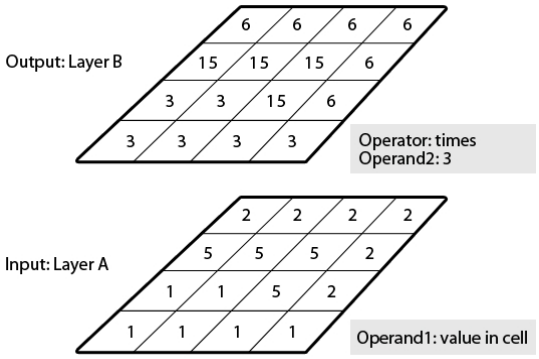
Basic advantage of **fuzzy logic** is an ability to mathematically intercept information expressed with words. In other words, it is able to work with an ambiguous terms often used in human language. Fuzzy logic gives a way, how to catch ICT resources – it means "less, significantly etc." – using a comparison. Advantage is also a search of information based on ambiguous or incomplete statement with a possibility to find incorrectly saved information.

Suppose an element a, we have to decide, whether the element belongs to a given set or not. To each element a (in the domain D) will be assigned an integer z, $z \in \langle 0;1 \rangle$, which expresses the grade of membership in the set (0 means: completely not included to the set; 1 means: fully included to the set). If we have a set of elements, in which each one is characterized by a grade of membership, we say it is the **fuzzy set** (Zadeh, 1965). The "classic" set can be understood as a special example of the fuzzy set, $z \in Z$, $Z \equiv \{O;1\}$.

Numbers z represents a membership function. "Classic" sets with exact borders h_1, h_2 can be defined as follows:

$$MF(a) = 1, \text{ if } a \in \langle h_1;h_2 \rangle$$

$$MF(a) = 0, \text{ if } a \notin \langle h_1;h_2 \rangle.$$



1: *Example of map algebra using one layer and arithmetic operator*

Fuzzy set can be practically express as follows:

$$A = (a, MF(a)), \text{if } \forall a \in D, \text{where } MF(a) \text{ is}$$

a membership function of element a in the domain A with values in closed interval <0;1>. Range of values of the function MF can be either the whole interval <0;1> or only few selected values. The MF function and the range can be defined by an expert in issue or using operations research methods. First way is used, when we model the semantics of the words of natural language. There usually occurs a situation in real life, when a person (expert) defines point A, which is still not included in a set, point D, which is already not included in the set, interval of values <B;C> with the grade of membership 1 and intervals <A;B> <C;D> interleaves with a suitable function which approaches the grade of membership in the points in these intervals (see Fig. 2). Method described in this example is called parametric method (Novák, 1986).

Fuzzy set is to a great extent determined by the membership function, which it belongs to. The selection of the membership function influences the borders of a fuzzy set (see Fig. 2).

As it was said above, geographic IT are able to model the landscape around us. Some elements of the landscape have their exact borders such as limits. It is hard to staking out borders of some phenomenon such as waterlogging. It is often inexplicit, how correctly define for example the possible border of land slope. Especially suitable and required is a possibility to capture the uncertainty during modeling aspects of the quality of live. It appears necessary in these cases to introduce an uncertainty into the geographic IT in the form of fuzzygeoelements.

Fuzzygeoelement is a geoelement, which except geometry, topology, attributes and time also has own membership function. Basic fuzzygeoelements are fuzzypoint, fuzzyline and fuzzypolygon (Machalová, 2004).

Each type of fuzzygeoelements is dependent on the membership function. Its modeling is based on the concrete membership function. In raster storage of information there are values of each cell calculated on the basis of the membership function and the distance of the cell from the cells with the value of the membership function equals one.

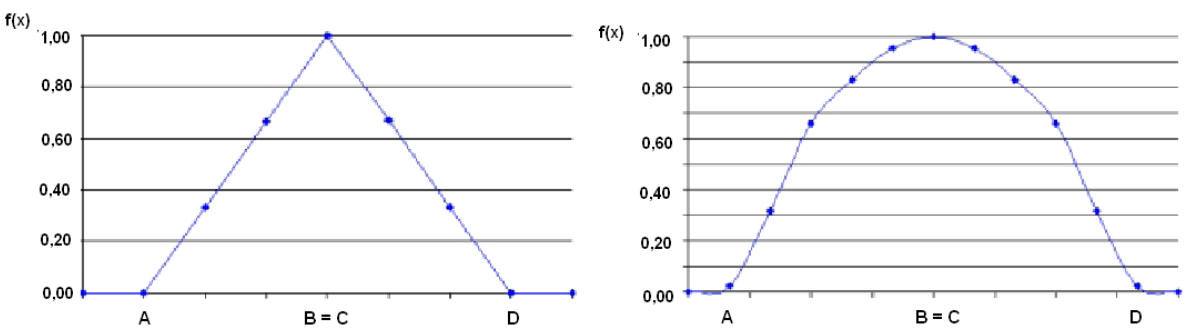
Fuzzypoint is a fuzzygeoelement, which is given by the ordered triad *F, A, M,* where *F* is a membership function, *A* (with coordinates *x, y*) is a cell with a value of the membership function equal to one, and *M* is a set of describing (attribute) values of the fuzzypoint (Machalová, 2004).

Fuzzyline is a fuzzygeoelement, which is given by the ordered n+2-tuple *F, A1, A2, …, A_n, M,* where *F* is a membership function and A_1 to A_n are neighboring cells with the membership function equal one. A_i only has neighbors A_{i-1} and A_{i+1}, A_1 only has a neighbor A_2, and A_n has only A_{n-1}. *M* is a set of describing values of the fuzzyline (Machalová, 2004).

Fuzzypolygon is a fuzzygeoelement, which is given by the ordered n+2-tuple *F,* A_1, A_2, …, A_n, *M,* where *F* is a membership function and A_1 to A_n are neighboring cells with the membership function equal one, which fill contiguous space. *M* is a set of describing values of the fuzzypolygon. Fuzzypolygon, which meets requirements of the previous definition, is a fuzzyline.

Fig. 3 shows a fuzzypoint, fuzzyline and fuzzypolygon in raster representation.

To be fuzzygeoelements usable for the requirements of spatial analysis, it is also necessary to define geometric and topologic relations. We can use Euclid metric, position of each cell define by the position of its center, distances between cells by the distance of their centers. Distances between fuzzypoints are of three types: minimal, middle, simple. Also there are defined connections of fuzzylines, in-



2: *Fuzzy set with a linear and parabolic membership function*

tersection of fuzzylines and fuzzypolygons and adjacency of fuzzypolygons (Machalová, 2004).

OUTCOMES AND DISCUSSION

According to notice No. 500/2006 about territorially-analytic background are on the level of municipal corporation with regional competency monitored the territorial system of ecological stability, national park, protected landscape area, national nature reserve, nature park, nature monument, memorial tree, biosphere reserve UNESCO, geopark UNESCO, NATURA 2000, locality of occurrence of the particularly protected species of plants and animals, protecting forests, special purpose forests, commercial forest, borders of biochore, surface water resources, protected area of water accumulation, water system of surface and underground water, water reservoirs, flood areas, nature medical resource, areas with deterioration of air quality.

Within the frame of mentioned notice is also monitored the landscape character, whose evaluation process is not wide united. Landscape character influences the land use, important landscape elements as well as the visual characteristics (visibility, slope, orientation to cardinal points, sun exposure).

The process is separated into two parts. The environment is analyzed separately, and the landscape character is analyzed separately, too. These two parts are integrated, at the end. The vector layers describing phenomenon character above come into the process of evaluation of working selectable conditions. The layers are rasterised consequently. The layer of digital terrain model (DTM) is raster; every pixel contains information about the elevation above sea-level. Digital terrain model is converting to triangulate irregular network (TIN). Sun exposure is calculated as average during whole year, with average elevation above the terrain.

The environment phenomena about water sources, memorable trees, and especially protected species of plants and animals have fuzzy character, we can be fuzzyficable. Considering its character the landscape character phenomenon are fuzzyficable. The phenomenons are thematic separated to subgroups. These subgroups are processed with map algebra. The resultant layers, that represented individual subgroups, are multiply by coefficient that constitute lever of the group. The last analyze in the part is again map algebra. The reintegration of two parts proceeds through the use of map algebra, too.

The environment part is separates to subgroups UNESCO, national, local, woods, water. The Fig. 4 graphically shows the process of working the environment part.

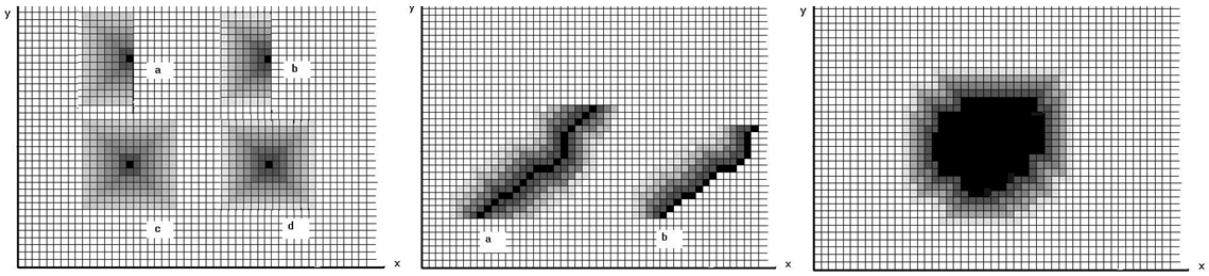
The evaluation of landscape character is separated only to three subgroups. Land use and important landscape elements are separately. The visual characteristics are the third group. Fig. 5 graphically shows the process of landscape character part.

Fig. 6 graphically shows the resulting processing with the aid map algebra.

For the using fuzzy sets in these situations it is necessary to proceed in three steps:

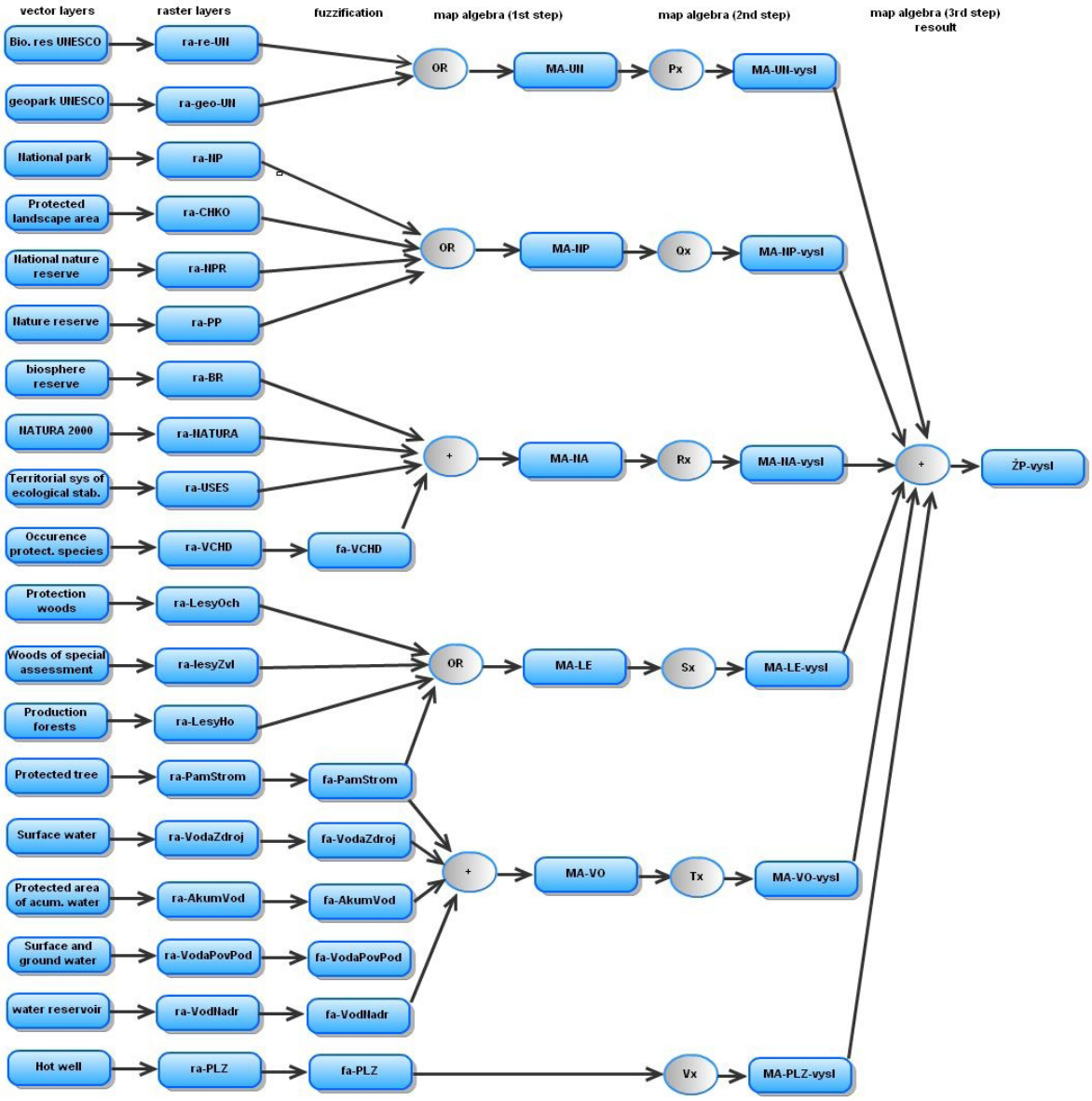
1. The correct definition of membership function and values A, B, C and D (see Fig. 2).
2. The concentration of quality input data; the quality is determined by accuracy, closeness, and topicality (Lake, 2008).
3. The modeling of fuzzy sets and the realization of spatial analyses.

The solving of first and second steps is not the main benefit of this paper. The correct definition of fuzzy sets is mission for experts in solving problem. In this paper there is taking advantage of result of marketing research (concrete the controlled discussion). The step two can be critical for success of the project, because it is important to find compromise between the image resolution and the file size, if we use raster layers. We are limited by execution of computer. This paper is innovation by the way of access to solving third step, firstly. The power of geographic information systems is in its analytical possibilities. The advantage of this methodology is variability thanks to coefficients, which can take into consideration the concrete analyzed territory, too.



3: *Fuzzypoint, fuzzyline and fuzzypolygon in raster representation*

Micro-region Babí lom is situated in the foothills Chřiby and Ždánický forest. Malá ostrá is the highest peak above sea level at 480 m. However, there are obvious Kyjov hills with the peak Babí lom. It followed form analyse of visibility. That why the visibility is used from broadcaster on the top of Babí lom (part landscape character). Fuzzification of polygons of visibility has linear membership function and it



4: *Graphically illustration process of environment part*

represents the show-through the trees and the visibility between houses. Other visual characteristic (slope, orientation, sun exposure) have during fuzzification parabolic membership function. The reclassification is made after fuzzification.

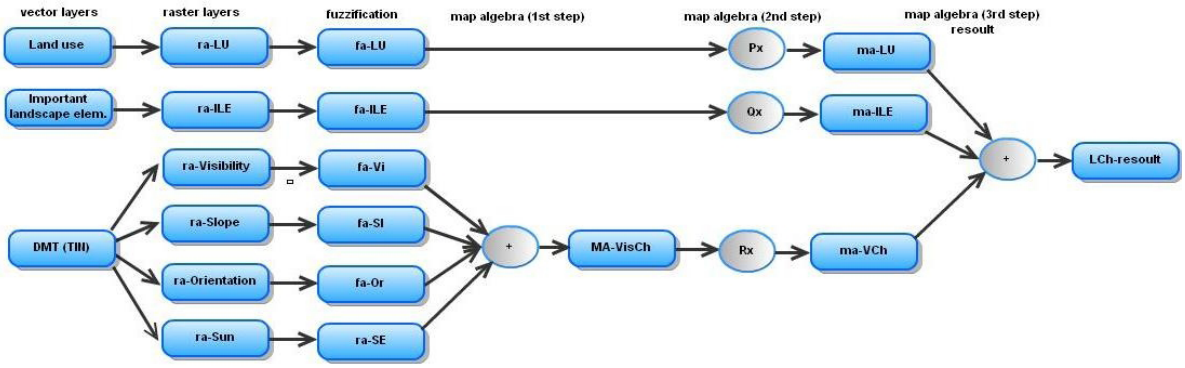
Territory is intensively used for agriculture (viticulture). There are also forests and meadows. River Kyjovka and stream Trnkmanka flow through the territory. Land use is evaluated on municipality level in keeping with dominant type of surface. After fuzzification there are municipalities markedly agriculture, mostly viniculture …

There are layout areas within the frame of the territorial system of ecological stability. There are no peat-bogs, ponds or lakes. Many significant landscape elements there are crosses, columns of cultural importance and the monuments; there are dislocate in built-up part of municipality, and in countryside.

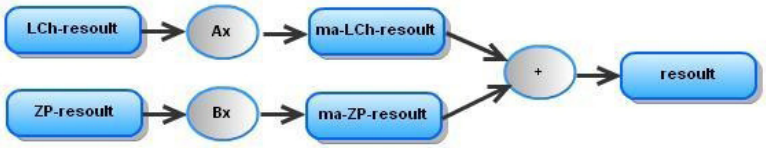
Digital terrain model and the select layers of the Basic base of geographical data of the Czech Republic are the source data. Czech Office for Surveying, Mapping and Cadastre (COSMC) is the author of these data. The data of T. G. Masaryk Water Research Institute are used too. The data of Municipal Corporation are suitable complementation.

Because of the range limitary of this paper it is possible to present only result of two parts and the resulting presentation of the monitored selectable factors. The description of the methodology would have want of more space, because the present pictures are result of the tens steps.

Only the some indicators (mentioned in methodology on Fig. 4) are in the monitored area. The results of analyses are present on Fig. 7. We can see



5: *Graphically illustration process of landscape character*



6: *Graphically illustration of the resulting processing*

that this indicator is positive influences by presence of woods, territorial system of ecological stability, and nature memories. The around of surface moisture and memorable trees is important, too.

The coefficients R, S, and T (see Fig. 4) were establish on the basis of interrogation to expert from department of environment and expert from information centre on Kyjov municipality (the other subgroups do not occur in this area):

$$1 * [\text{MA-VO}] + 4 * [\text{MA-LE}] + 20 * [\text{MA-NA}].$$

The fuzzification plays important role in landscape character part, because it concerned in all layers. In subgroup visual characteristics there were more positive evaluate areas with higher sun exposure, orientation south, and with lesser slope. It was chosen on the basis of interrogation to expert from information centre on Kyjov municipality, and two owners of significant lodging places in micro region.

Fig. 8 shows the visual characteristic, land use, and significant landscape elements. Coefficients P, Q, and R (see Fig. 5) were chosen on the basis of interrogation to expert from information centre on Kyjov municipality, and two owners of significant lodging places in micro region, too:

$$2 * [\text{fa-LU}] + 4 * [\text{fa-ILE}] + 1 * [\text{ma-VisCh}].$$

Landscape character does not embody marked differences. Top of Babí lom sticks out positively, that is really dominants in region (the name of this micro region is according to it). The territory of Sobůlky is interesting in this point of view.

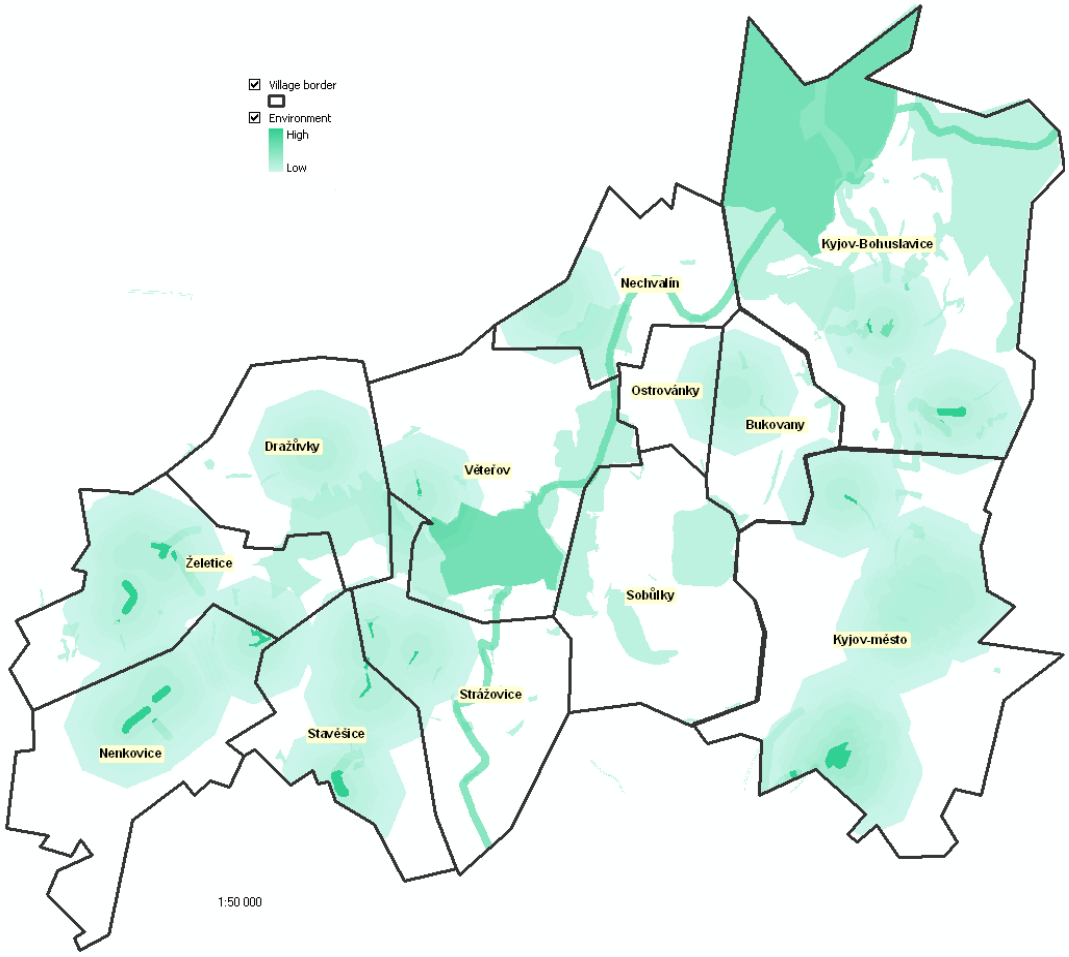
9: Resultant evaluation of monitored selectable indicators in micro region Babí lom

Fig. 9 presents the result of map algebra. The both parts environment and landscape character were input to this analyse. Coefficients A and B were discussed with expert from department of environment, expert from department of landscape planning, and expert from information centre on Kyjov municipality, with head of micro region Babí lom, and with two owners of significant lodging places in micro region:

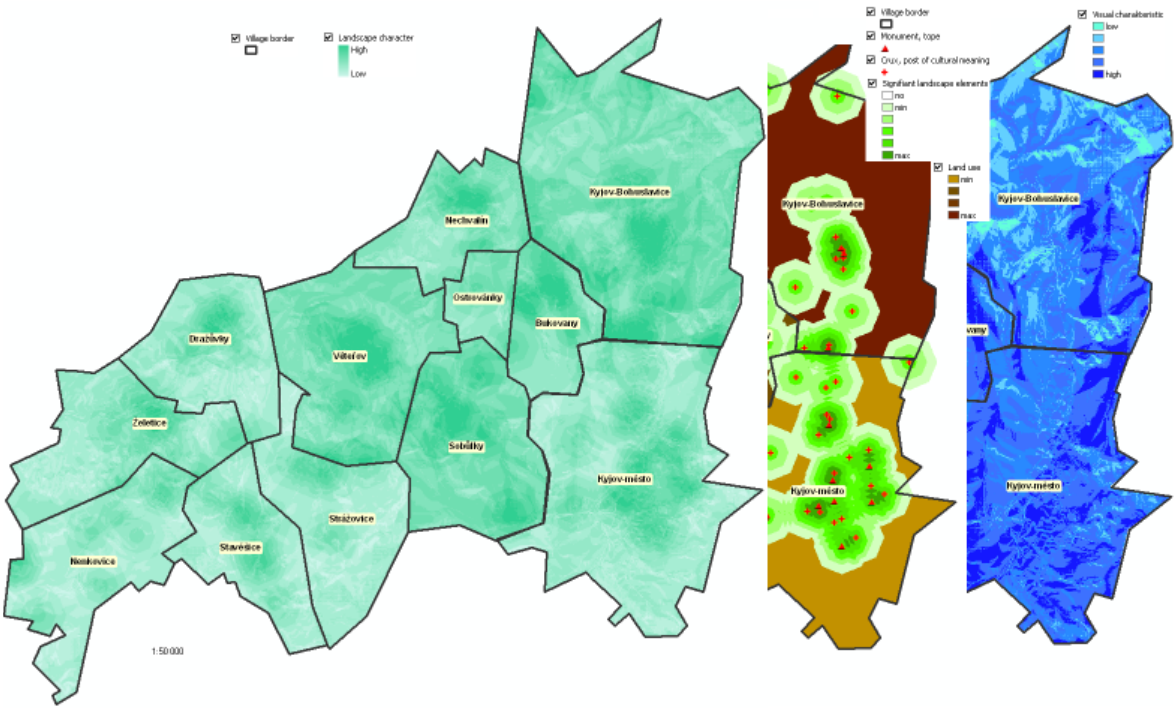
$$1 * [\text{ma-LCH-resoult}] + 3 * [\text{ma-ZP-resoult}].$$

From the result there is obvious, that monitored selectable factors are the most positive in the woods, which are the part of the territorial system of ecological stability on the north Kyjov cadastre, and around Babí lom in Veteřov cadastre.

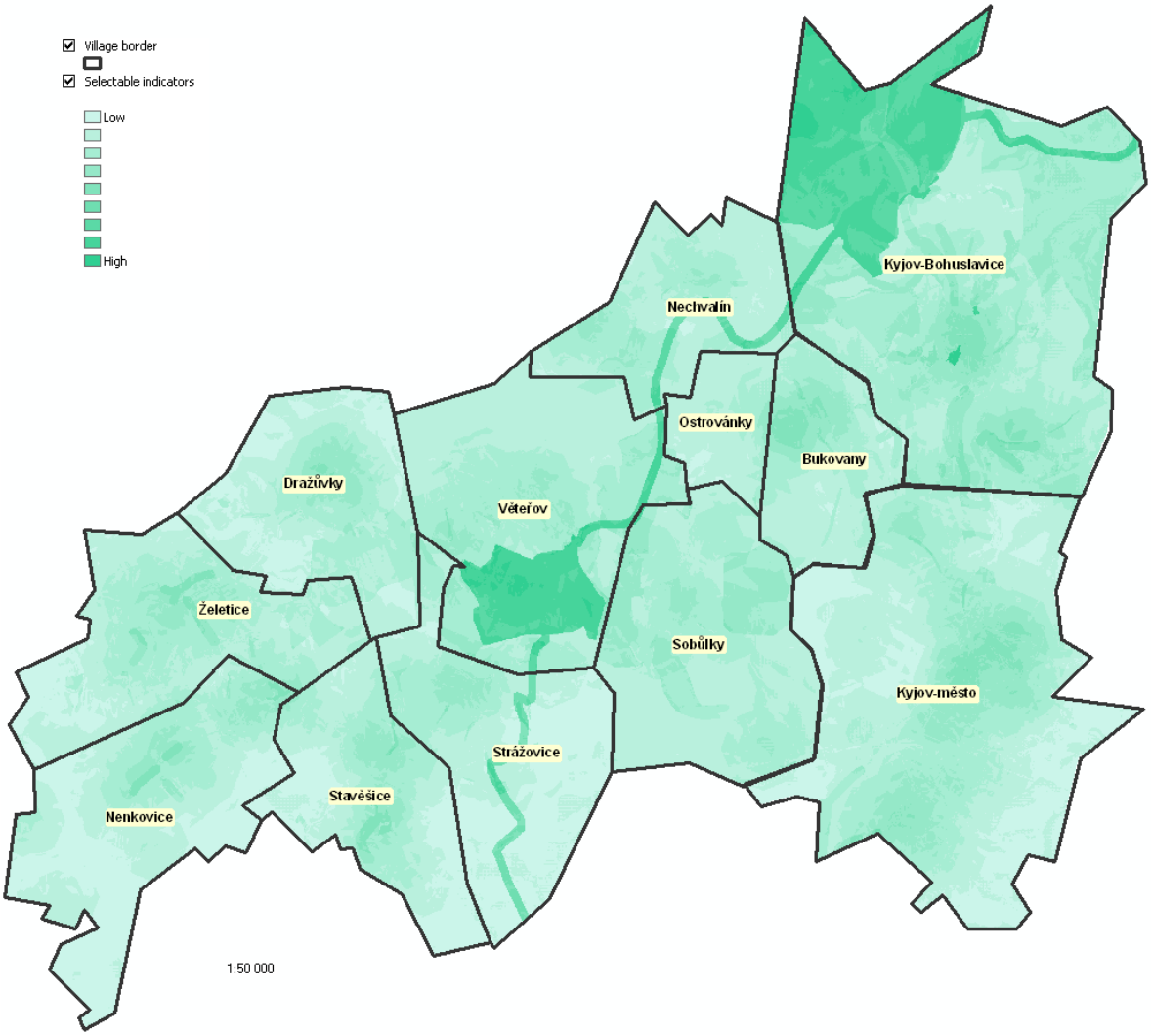
The monitored area is not wide, and this area is compact from analysed selectable factors point of view. The differences would be more marked, by usage methodology on the large area. It would call for extremely high-capacity computer. It would be necessary to use lower graphic resolution; it could have negative impact for local using. The using designed methodology verified that the top of Babí lom is significant in micro region not only its spatial dominance, but the environment state, too. The methodology makes possible dynamic change the coefficients, which are the weights of criteria, thereby the methodology adapt to concrete conditions.



7: *Environment*



8: *Landscape character (underlying cuts of evaluation of visual indicators, land use, and significant landscape elements*



9: *Resultant evaluation of monitored selectable indicators in micro region Babí lom*

SUMMARY

Factors affecting tourism are usually divided into three groups: localization, implementation and selective. Selective factors are objectively assessed (political stability, economic, legislative and administration conditions) and subjectively assessed (environment, landscape character). The aim of this paper is to make methodology of evaluation of introduced subjective selectable factors. A lot of information exists about the environment at present. However, environment indicators have not been unified. Significant support in decision making processes used to be information systems. In the case of decision making in a field adherent to the landscape, the geographic information systems are used. Tourism is inextricable connected with spatial. Map algebra is a tool able to process raster representations of reality using the language of map algebra. Fuzzy logic is able to work with an ambiguous terms. It would be profitable to introduce an uncertainty into the geographic IT in the form of fuzzy-geoelements (fuzzypoint, fuzzyline, fuzzypolygon).

The process is separated into two parts. The environment is analyzed separately, and the landscape character is analyzed separately, too. These two parts are integrated, at the end. The environment phenomena about water sources, memorable trees, and especially protected species of plants and animals have fuzzy character. Considering its character the landscape character phenomenon are fuzzyficable. The advantage of this methodology is variability thanks to coefficients, which can take into consideration the concrete analyzed territory, too. The concrete coefficients were selected as result of controlled questioning of experts in these problems, and with seat in monitored locality. The using designed methodology verified that the top of Babí lom is significant in micro region not only its spatial dominance, but the environment state, too.

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