Knowledge based spatio-functional optimisation of urban environment

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Abstract

The purpose of this paper is to optimise the intensification process in the Banská Bystrica city built up area by considering a number of decision criteria and several different decision-making schemes. The city was chosen due to its intensive development during the last decades that (among other factors) has resulted in urbanely unused areas spreading over 10% of the city built up area. These provide the main potential of intensification and are the focus of this study. We tried to delimit, on the bases of multicriteria decision-making techniques, the categories of urbanely unused areas by their general suitability for urban functions allocations. This was based on the synthesis of 10 decision criteria and ten expert judgements. While the criteria itself might be considered as highly objective, their ranking and judging their mutual importance appear as quite subjective process. In this view, just the cohesion of expert judgments implies the portion of subjectivity stepping in. Final rank of decision criteria was derived by means of expert judgements synthesis done by using two aggregation schemes - average values and results of Principal Component Analysis. While the use of average values to synthesize expert judgements might lead to biased result, mainly in the cases of inconsistent experts group, the Principal Component Analysis brings certain order into confusing data set. In this way three different tendencies in expert's opinions were extracted and respective interpretations were proposed. Using this information, the urbanely unused areas of the city were classified into the three categories – those providing low, average and high potential for urban functions allocation.

Funkčno-priestorová optimalizácia urbánneho prostredia

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Abstrakt

Cieľom tohto príspevku je optimalizácia intenzifikačného procesu v zastavanom území mesta Banská Bystrica uvažovaním väčšieho počtu kritérií a niekoľkých rozhodovacích schém. Banská Bystrica bola pre túto štúdiu zvolená z dôvodu jej intenzívneho rozvoja v posledných desaťročiach, ktorý (medzi inými faktormi) vyústil do existencie mestsky nevyužitých plôch pokrývajúcich 10% rozlohy zastavaného územia. Tieto plochy tvoria databázu slúžiacu ako východisko rozhodovacieho procesu. Tento bol založený na posudzovaní 10 kritérií a 10 expertných posudkov. Zatiaľ čo rozhodovacie kritériá môžu byť považované za vysoko objektívne, posúdenie ich vzájomných vzťahov je naopak subjektívnym procesom. Z tohto uhla pohľadu práve určitá kohéznosť jednotlivých expertných posudkov určuje mieru subjektívnosti vstupujúcu do rozhodovacieho procesu. Poradie, resp. relatívna dôležitosť použitých rozhodovacích kritérií bola určená syntézou expertných posudkov využitím dvoch agregačných schém – ich priemernej hodnoty, a interpretáciou jednotlivých komponentov odvodených metódou hlavných komponentov. Každý z týchto postupov vytvorí odlišný model optimálneho využitia územia. Využitím tejto metódy sme určili tri odlišné tendencie prítomné v expertných posudkoch a navrhli príslušné interpretácie. Využitím týchto informácií boli mestsky nevyužité plochy Banskej Bystrice klasifikované do troch kategórii, na základe všeobecného potenciálu pre lokalizáciu urbánnych funkcií.

Introduction

Radical change of social and economic conditions at the turn of 80`s and 90`s in Eastern and Central Europe countries had started intensive transformation processes of urban structures. Predominant trend became a shift from the extensive to intensive urbanisation, and intensification processes became the most distinct expression of urban-transformation. While in well-developed economies these processes were proceeding fluently for decades, the specific feature of Eastern and Central Europe countries is almost equal footing and relatively rapid rate of change. The result of that is quite chaotic city development, unsuitable allocation of urban functions and forcing individual investor's intentions upon urban development plans. These facts are, in general, the results of missing decision and controlling mechanisms guiding these processes. Leaving aside legal issues, the solution of that provides the knowledge-based assessment of the functional and investment attractiveness of the territory under consideration by means of various decision-making techniques.

The purpose of this paper is to optimise the intensification process in the Banská Bystrica city built up area by considering a number of decision criteria and several different decision-making schemes. The city was chosen due to its extensive development during the last decades that (among other factors) have resulted in urbanely unused areas spreading over 10% of the city built up area. The decision process aimed at categorizing them according to their general suitability for urban functions allocation by the synthesis of 10 decision criteria ranked according to 10 expert judgements. While the criteria itself might be considered as highly objective, their ranking appears as quite subjective process. In this view, just the cohesion of expert judgments implies the portion of subjectiveness stepping in.

In general, any decision-making technique comprises both objective and subjective components. As definitively objective might be considered the information derived from the data gathered by direct field measurement, or those taken from relatively reliable sources. On the contrary, the subjective component appears everywhere where the man's personal attitude steps in. This is mainly the choice of individual decision criteria, judging their relative importance with regard to the purpose followed or interpretations of particular results. By increasing the number of decision criteria and decreasing the entropy of input information, the subjective component plays a smaller rule.

Final rank of decision criteria was derived by means of expert judgements synthesis done by two aggregation schemes - average values and first three components of PCA. Logically, all of theses approaches give a different proposal on land allocation within the territory considered. These have been compared and respective consequences were derived. Using this information, the urbanely unused areas of the city were classified into the three categories – those providing low, average and high potential for urban functions allocation.

Spatio-functional optimisation of urban environment

Urban environment is the most dynamic component of the culture landscape. Dynamics in the changes of its natural components arrangement, population distribution, and changes of morphological substructures and functions impress often surprisingly. Since the cities take, among other functions, a function of innovation spreading centres, they are expected to use recent techniques guiding and controlling their development. Besides, relatively high information availability in these environments facilitated the development of complex municipal spatial information systems as effective tools for knowledge based urban environment optimisation.

There are several groundworks providing theoretical background of spatial analyses focused on this field. Important works published in Slovak are those by Kusendová and Lauko (1992), or Mandzak (1993) analysing a city spatial structure within the frame of digital geodatabases, or prognosing urban development (Divinský and Pauditšová (1999). The early works evaluating large amounts of data by means of expert judgments were published by Bašovský, Paulov and Ira (1981). Since this area strongly relates to the knowledge-based optimal land allocation methodologies, the works from the field of landscape ecology and landscape planning are quite contributive. These are mainly those by Ružička (2000), Miklos et al. (1998), Izakovičová et al. (1992), Miklisová (1991) and others. Works joining the use geoinformation technologies and expert judgements are for example those by Pouš, Hlásny and Krátka (2001) to optimise the greenery allocation within the Banská Bystrica city built up area, Pouš and Hlásny (2004) to analyse certain urban-transformation processes, or by Székely (2002) to allocate science-technology park in the Bratislava city.

The works published abroad providing the background of this study are those by Gautam (2003), Pinnel, Dockrez and Borning (2004) devoted to specific aspects of urban area optimisation, and those by Chrisman (1996), Jiang and Eastman (2000), Eastman (1999), Eastman, Jiang and Toledano (1995) providing general theoretical background of multicriteria decision making and of further specific approaches.

On these bases, the properties of knowledge-based optimisation of urban environment (of course not only) might be summarized as follows:

Multiciteria nature, i.e. the ability to judge objectively a large number of decision criteria. This need is implicitly given by the character of urban environment, such as highly complicated and dynamic component of the cultural landscape the sustainability of which depends on effective dealing with spectrum of spatio-temporal information.

Operationality, i.e. the ability to respond dynamically to the change of input conditions, or end-users requirements. The example of that is the alteration of the weighs assigned to individual factors, following for example, the shift from directive approach to urban planning (plot = function) to the trade driven planning, or to planning based on detailed judging respective parcel urban potential. In this way, respective urban functions allocation became more relaxed and opposite to actual needs of the society.

Objectification, i.e. the ability to avoid incorrect decision due to both deliberate and accidental subjective inputs. This might result from the nonfeasance or, on the contrary, prioritising certain facts, often without giving exact reasons on it. This property positively correlates with both the number of decision criteria and the cohesion of expert's inputs.

Retrogressive controlling, i.e. the ability to follow thorough decision flow backwards, in order to reduce the extent of corruption, directive decision making, or subjective prioritisation of individual interests upon strategic urban-development plans

The workflow

The workflow of decision making for optimal land allocation has been described by many authors, till now. The following introduces the general bases of this process, as broadly known, but altered by our perception and experiences drawn upon practical applications in urban environment. Individual steps are approached from the general perspective, thus the field of applications might be much broader. The workflow is as follows.

Data gathering and processing, the step focused on the development of primary database containing both the spatial and attribute data about the area of interest. This implies close collaboration with municipal institutions supervising individual parts of municipal geodatabase (City Architect`s Office, Cadastre Institute, etc.), and with other private, governmental and nongovernmental organisations involved in municipal policy.

Decision frame definition, this step is to define the *purpose* (or purposes, in the case of multi-objective analyses) of decision process, *criteria* increasing or decreasing the suitability of individual parts of urban space with regard to the purpose followed, and *constraints* that limit, in positive or negative manner, certain areas. Positive limit is, for example, the position in the biocorridor, in the case of greenery allocation. Negative limit might be, in the case of housing allocation, a water body.

Evaluating space potential step is to transform real units, measured in the field, or extracted from the secondary sources, to *suitability scores* taking on a range given by convention as 0-1, or 0-100, respectively. The transformation might be either linear, or non-linear (e.g. the case of individual housing allocation that is low close to rivers, due to the danger of floods, but it might slightly decrease getting too far from, due to the positive micro-climate provided by the water body). The function transforming real units to those of suitability might sensitively reflect both the needs of practice, structure of input data and expert's opinions. This step along with weighting, is the most flexible and sensitive of all the decision process.

Expert judgements analysis and synthesis step is to put individual factors into the decision process objectively. The crucial, and to the subjective influence the most sensitive step, is to rank individual criteria by their relative importance with regard to the purpose followed (their equality is not a real case, mostly) and to derive, on these bases, appropriate weights. To reach a maximum objectivity, a larger number of judgements are required to guide this process. Logically, this might contain contradictory tendencies, thus a poor result could be obtained. This might be solved by extracting one or more representative courses from the judgements, instead of one, simpler, but insufficiently fitting the structure of input data. This will be discussed in more details below.

Synthesising step is to aggregate all the criteria and constraints to construct final suitability model. A general notation is as follows

$S = 1 \; if \; c = 1$

otherwise

$$S = \sum_{i=1}^{n} w_i x_i \prod_{j=1}^{m} c_j$$

where S expresses the suitability of analysed area for the objective under consideration, x are the factors involved, w relevant weights derived from expert judgements, c are constraints taking either 1 or 0 values, and n and m expresses the overall number of criteria and constraints,

but, in practice, also different aggregation operators might be used. To make this step more sensitive, in the case of competitive multi objective land allocation, outstandingly high suitability scores of one factor might artificially decrease the scores of factors related to competitive purpose.

Classification is to discriminate areas, which, after the synthesis, have not reached the threshold defined, and to rank those remaining.

Backward tuning of decision scheme is to confront the results obtained with overall decision process and to find out the reasons of respective discrepancies between the results and experts expectations. The rule is that the tuning must not come into the manipulation.

Interpretation is to confront the result of all the steps above with experts (again) and official planning materials, and to formulate exact reasons for the selection of sites that "passed". The backward tuning might follow this step again.

Case study

The ideas above where demonstrated in the Banská Bystrica city built up area. This is a part of more complex study focused on both urban space optimisation and on the analyses of various urban transformation processes. Recent results might be found in the works by Pouš and Hlásny (2004), Pouš, Hlásny and Krátka (2002), Hlásny, Pouš and Krátka (2001) and Pouš (1998).

The purpose of the case study is to delimit, on the bases of multicriteria decision-making techniques, the categories of urbanely unused areas by their suitability for urban functions allocations. We do not intend to eliminate a human factor, but to increase the possibilities of controlling mechanisms. The purpose also was not to substitute well-known and broadly used urbanist and urban planning methods, but to contribute to the objectification of the decision process within their frame.

A crucial indicator of the urbanely unused areas integration into the city functional structures is their potential reflected in respective suitability score. The potential is understood as a result of co-influence of variables related to further exploitation of particular area. In practice, the suitability is being judged consequently for individual urban function (housing, recreation, public service facilities, etc.), what requires a large number of specific evaluation criteria, however. The extent of this study, relatively small number of evaluation criteria (10) and rather weak sensitivity of this approach do not allow such a procedure. Therefore, the suitability will be approached as general attractiveness for urban exploitation given by the synthesis of partial suitability scores. The expectation in practice is that the areas providing higher suitability scores should be transformed in a shorter time.

The Data

High spatial and functional heterogeneity is a characteristic feature of the Banská Bystrica city. During the last 50 years, the city has overcome a period of significantly extensive growth, resulting in the presence of a number of urbanely unused areas, providing spatial reserves for building densification. Since these are, in most cases, thoroughly locked in the city built up area, they are inevitable to merge with the city, as its urbanely functional parts. Due to the lack of space in the city, these logically became a focus of investors. Thus 303 mapped urbanely unused areas accounting for 9,58% of the city built up area (Annex. 1) provide the primary database for the city built up area optimisation. Since during the last years some of them have already become urbanely functional, these might be used as the validation set of a model constituted. To facilitate the decision process, a comprehensive set of attribute information is linked to each area. The database was developed and analyses were carried out in the GeoMedia Professional, STATISTICA and IDRISI 32 environment.

The Criteria

Firstly, the set of all the criteria available was defined and those important for the purpose followed were chosen. In this study mainly the criteria directly measured in the field, derived mathematically or by cartometric analysis were used. Those missing are for example ownership relations, prices of plots or engineering networks accessibility. Despite just these are outstandingly important for the investment attractiveness evaluation, the criteria processed provide sufficient bases for the decision process. Those used in further analyses, inclusive brief characteristics are the following:

Kind of urbanely unused area. From this perspective, the four categories were distinguished – unused areas (in general sense), devastated areas, arable land and permanent cultures, each of them having different potential for investments.

Position towards central city zone. Central city zone is deliberately delimited area around the city functional centre (exactly defined in urban planning documentation), where the most intensive space exploitation is planned and the most important urban functions are to be allocated there. Preliminary, the highest attractiveness of the city spatial reserves might be supposed. The areas are attributed as 1 / 0.

Distance from the city functional centre. In general, the intensity of townuse growths towards the city functional centre. In the trade economy conditions, the price of plots follows this trend, reflecting the attractiveness for investors.

Size. Spatial extent of the area belongs to the most important evaluating criteria, since it indicates potential polyfunctionality in the future.

Compactness. The importance of this factor comes from the consideration that compact areas, e.g. square shaped, provide much higher urban potential than the areas of the same size, but spatially fragmented, or composed of the belts of various length and width.

Slope. Higher slope of the area decreases its attractiveness for most (not only urban) social-economic functions, mainly due to the growth of initial investments.

Slope aspect. Aspect relates mainly to the allocations of housing functions, while in the other cases it doesn't play a rule, mostly. It influences general living contentment and also the energetic balance of buildings.

Position towards climate inversions. Climate inversions along with aspect also take a rule in housing functions allocation. The factors such as changes in temperature, sunshine, frequency of foggy, or increased pollutants concentration days strongly influences housing contentment and energetic balance of respective houses. In the case of Banská Bystrica city areas of this kind spread mainly in narrow and deep valleys of rivers and streams with significant accumulation of the cold air. Besides, traffic and industry allocations negatively contribute to the air pollutants concentration there.

Accessibility. Accessibility is, according to neoclassic economic school, along with size and position, one of the most important factors related to the attractiveness of the area under consideration. Since in the city the highest portion of transport both people and material accounts for automobiles, the accessibility by road communications will be a crucial factor of further analyses.

Distance from the city built up area edges. This is a complementary factor to the distance from the city functional centre. The reason of its including is low compactness of the city (in geometric sense) (Annex 1). Practically, it means that the areas lying close to the city centre might be also close to the city edges, and, on the contrary, those lying farer from the city centre might be allocated deep in the city built up area. From this perspective, the use of only one of these two factors could give biased result. We assume that since the city growths by horizontal addition, mainly, the areas lying deeper are much rare than those in the peripheral parts (if the database of spatial reserves exists, it might be analytically proved easily). Besides, their presence there is much more disturbing than at the periphery, thus the effort to merge them with the city is very intensive.

After having collected all the input criteria, these are to be standardized into the unique scale to express the suitability for the purpose followed, instead of real units of measurement (slope, distance, etc.). In order to facilitate expert judgements elaboration, this step was rather simplified and five suitabili1y categories were established, where the fifth one expresses the highest suitability.

Expert Judgements

Knowledge based decision-making could not be definitely free from the human factor. In this procedure it is necessary to judge mutual importance of the criteria considered, to prioritise those of a large importance and, if needed, to discriminate some of remaining. This process is the most sensitive part of decision-making, mainly due to its sensitivity to incorrect subjective influences. To minimize this factor, 10 independent experts were asked to elaborate the judgements, rank the criteria considered and to assign the weights to each of them. In order to consider wide range of aspects related to urban planning, the experts group consisted of urban planners, geographers, landscape ecologists and environmentalists (to keep their privacy, the judgements will be number from 1 to 10). Logically, this range of expert's professions gave quite inconsistent set of opinions, difficult to be used directly (Tab. 1).

Exp. Judg. No./ Criterion	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Kind	0.0	1.0	2.0	3.0	0.0	3.0	0.0	2.0	5.0	1.0
Position	5.5	4.0	3.0	6.0	7.0	8.0	8.0	4.0	6.0	5.0
Size	7.0	3.0	1.0	9.0	2.5	5.0	7.5	4.5	7.0	7.0
Compactness	8.0	5.5	4.0	8.0	6.5	6.0	6.0	5.0	0.5	9.0
Slope	4.0	7.0	9.0	7.0	5.5	4.0	5.0	1.0	2.0	4.0
Aspect	2.5	6.5	5.0	4.0	4.0	2.0	2.0	5.5	3.5	3.0
Accessibility	9.0	8.0	6.0	5.0	7.5	7.0	8.5	8.0	8.0	8.0
Clim. inversions	3.0	4.5	7.0	1.0	2.0	1.0	1.0	6.0	1.5	2.0
Distance centre	4.5	5.5	8.0	2.0	8.5	9.0	4.0	9.0	9.0	6.0
Distance edges	1.5	0.0	0.0	0.0	1.5	0.0	3.0	0.0	2.5	0.0

Tab. 1. The weights assigned by 10 experts to 10 criteria to judge the general suitability for urban functions allocation. Criteria interpretation is according to the text above.

As stated above, just the consistency of expert judgements implies the degree of objectiveness / subjectiveness of final decision. The (in)consistency might be analytically proved by designing and evaluating the correlation matrix of expert judgements (Tab. 2). It can be seen that a lot of zero approaching correlation coefficients indicating the discrepancy in expert's opinions have occurred. Since negative values are not present, there are no definitively contradictory tendencies. As can be seen, mainly the judgements 2, 8 and 9 correspond with none else. On the contrary, the judgement number 10 has parallels with numbers 1,4,5,6, and 7.

Expert Judgements No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	***1.00***	0.58	0.16	0.67	0.68	0.66	0.88	0.52	0.27	0.94
2	0.58	***1.00***	0.79	0.37	0.73	0.45	0.40	0.60	0.11	0.61
3	0.16	0.79	***1.00***	-0.02	0.55	0.28	-0.02	0.46	0.01	0.22
4	0.67	0.37	-0.02	***1.00***	0.32	0.45	0.68	0.01	0.04	0.72
5	0.68	0.73	0.55	0.32	***1.00***	0.83	0.65	0.60	0.37	0.73
6	0.66	0.45	0.28	0.45	0.83	***1.00***	0.68	0.58	0.65	0.77
7	0.88	0.40	-0.02	0.68	0.65	0.68	***1.00***	0.25	0.39	0.78
8	0.52	0.60	0.46	0.01	0.60	0.58	0.25	***1.00***	0.53	0.59
9	0.27	0.11	0.01	0.04	0.37	0.65	0.39	0.53	***1.00***	0.32
10	0.94	0.61	0.22	0.72	0.73	0.77	0.78	0.59	0.32	***1.00***

Tab.2 Correlation matrix of expert judgements above (see Tab. 1). Red marked those >0.7.

Due to the inconsistency in judgements a synthesis of them expressing, in certain manner, a representative tendency is to be proposed. Naturally, the arithmetic means appears as effective tool to do that. The result might be seen in the Tab. 3.

Criterion	Exp. judgements average
Kind of area	1.7
Position	5.65
Size	5.35
Compactness	5.85
Slope	4.85
Aspect	3.8
Accessibility	7.5
C. inversions	2.9
Distance centre	6.55
Distance edge	0.85

Tab. 3 Arithmetic means of the weights assigned by 10 experts to 10 evaluation criteria.

Despite easy computation and interpretation of this measure, there are several drawbacks of its use in this context. Firstly, to represent the tendency corresponding with most of the judgements, the normal distribution is required that cannot be ensured. Secondly, large group of independent expert could represent more then one tendency in weights assignment to prioritise the criteria. Using arithmetic mean, these merge in one value, and, in the worst case, none will be satisfied (for example in the case of multimodal distribution). Despite these facts, easy computation and interpretability makes this measure, especially its weighted variants, the base of this kind of analyses.

To solve this death end, the Principal Component Analyses (PCA), as non-parametric methods of extracting relevant information from confusing data set (Shlens, 2003), is to be used. This extracts from the correlated variables (it might be expected that judgments, because judging the same problem, will be) certain number of uncorrelated components that express a large portion, if not all, of the information variability of input variables. Since the components are uncorrelated, the unique tendencies in input data arrangement are expressed.

The outputs of this procedure are, among others, the portion of information variability explained by individual components, and so-called components scores. Components scores are hardly to be interpreted directly, but these are given by linear combination of input variables and might be used as respective weights. The details on their computation inclusive several geographical applications might be found in the work by Johnson (1978). Besides, the score loadings providing useful information on the relations between the inputs and outputs of this procedure can be inferred.

In the Fig. 1 can be seen the plot expressing the portion of variance explained by individual components. Can be seen that the first component explains 56.34% of the overall information variability contained in input judgments, second 17.96% and third 13.11%. The rest of them might be neglected, due to the relative insignificance. Cumulatively, first three components account for 87.5% of input information.

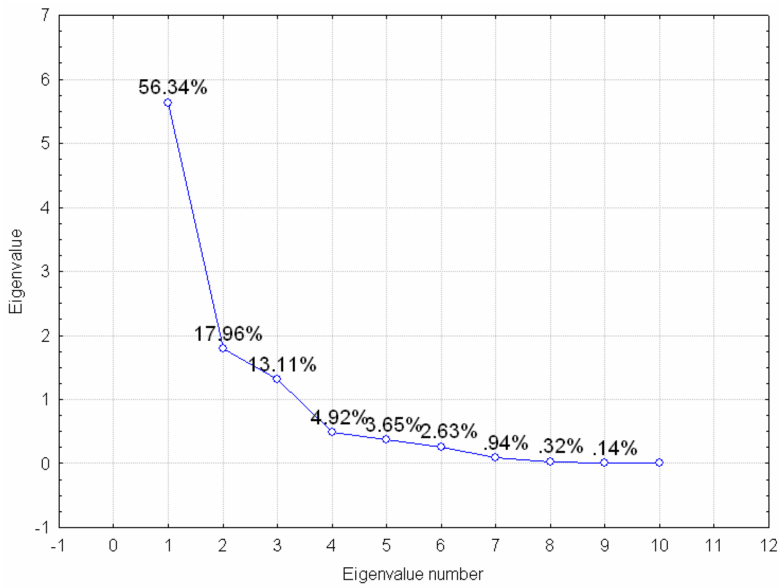

Fig. 1 Scree-plot of PCA. The portion of 10 expert judgements informational variability explained by individual components.

As stated above, the components scores derived from the judgements might be used directly as the weights of particular criteria. These can be seen in the Tab. 4. More detailed scores investigation could show the tendencies in judgements and relationships with input variables. Furthermore, the first component will be used, only.

	Component 1	Component 2	Component 3
Kind of area	-1.35566	0.186994	0.784247
Position	0.573921	0.762139	0.537015
Size	0.40117	1.718229	0.421435
Compactness	0.76047	0.725785	-1.34447
Slope	0.106625	-0.37369	-1.74753
Aspect	-0.35431	-0.79704	-0.44067
Accessibility	1.399745	-0.21842	0.405439
Clim. inversions	-0.78345	-1.25734	-0.52172
Distance centre	0.871424	-1.42756	1.505316
Distance edge	-1.61994	0.680906	0.400936

Tab. 4 Scores of individual components extracted from 10 expert’s judgement.

The Synthesis

After having collected all the input criteria inclusive respective weights, the synthesis might be carried out. This is based on the equation above, according to which the suitability scores of individual criteria are weighed and summed. As far as constraints, these were not considered. This is because the positively or negatively limiting criteria (constraints) relates mainly to the evaluation of particular suitabilities (e.g. for greenery or industry allocation) than to general one, which is the focus now. The weights are as the first component above. A part of the table showing this operation can be seen below:

Area ID		187	188	189	190	191	192	193	194	195
Size	*m^2*	3092	1160	97056	22412	672	1508	1032	596	1256
	suit. score	3	2	5	5	2	2	2	2	2
	weight	0.401	0.401	0.401	0.401	0.401	0.401	0.401	0.401	0.401
Dist. edge	*m*	51.5	29.9	429.8	545.5	426.8	297.2	661.6	545.4	661.3
	suit. score	1	1	5	5	5	3	5	5	5
	weight	-1.62	-1.62	-1.62	-1.62	-1.62	-1.62	-1.62	-1.62	-1.62
Climate	-	-	-	-	-	-	-	-	-	-
	suit. score	4	4	3	3	3	3	3	3	3
	weight	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78	-0.78
Compact.	*size/perim*	0.138	0.302	0.141	0.207	0.310	0.307	0.331	0.309	0.238
	suit. score	1	4	1	2	4	4	4	4	2
	weight	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Sum		-2.77	-0.89	-7.67	-6.91	-6.59	-3.35	-6.59	-6.59	-8.12

Tab. 5. The sample of the urbanely unused areas suitability scores synthesis. The sum expressing the general suitability of particular area in the low raw is given by the multiplication of individual suitability scores by respective weight and summing each column up.

As can be seen in the Tab. 5, using the weights given by the Principal Component Analysis results in many cases in negative values. In fact, this is not a problem, by to make the results better readable, the scores might be simply linearly rescaled into the range of positive values. After having computed the final scores for all the areas, these might be classified into the categories such as high/middle/low suitability. This might be seen in the maps in Annexes 2-4.

The Results

This study was to bring an alternative look at optimal land allocation techniques in the context of urban planning. As source data the database of urbanely unused areas of the Banská Bystrica city was used. With regard to relatively small number of evaluation criteria, we focused on the general attractiveness for urban functions allocation evaluation. To analyse the potential for more spacious green field investments, or for particular urban functions allocation, a broader spectrum of input information is needed. For these purposes, the 10 evaluation criteria used appeared as insufficiently sensitive and various decision schemes were producing approximately the same results.

The decision process was controlled by 10 expert judgements. These might be said to be rather miscellaneous and their mutual consistency was relatively poor. To use all of them individually appears redundant, since a lot of information repeats, i.e. judgements were up to the certain extent correlated. This led us to the idea of using the Principal Component Analysis, instead of arithmetic mean, or other simple aggregator. This gave us three different tendencies (expressed by individual principal components) presented in the judgements. With regard to the extent of this paper, only the first one, accounting for 54% of the source data informational variability, was used.

On these bases, the highest weights were reached by the criteria related to urbanely unused areas position towards important city components – **distance from the city functional centre**, **position towards central city zone** or **communications accessibility**. The morphological properties, such as shape and size of the area, appeared to be of second-class. The environmental criteria related to the natural and hygienic parameters of the plots (slope, aspect, climate inversions, etc.) took almost no importance. Thus, the economic aspect characterized by the spatial rent principles and profit maximisation took a dominant role, unambiguously. This can be also clearly observed in the maps in the Annexes 2-4. While the distribution of urbanely unused areas is relatively equal over the city (Annex 1), those reaching the smallest suitability scores are distributed mainly at the periphery (Annex 2), farer from the city functional centre and from the main traffic corridors. Also the negligible size is typical of them. These providing average suitability are mostly of a larger size, and significant shift from the periphery to the city parts with longer urban tradition can be seen. The most suitable areas are distributed, almost strictly, in the central city zone with good access from the main city radials. The size does not play important rule and the prices of plots are, in general, high. Besides, this city part exhibits the highest intensity of building, the smallest portion of greenery and the worst hygienic and environmental conditions. This corresponds to the trend mentioned above.

This confirms recent trend in Slovakia, which identifies townuse optimisation with building densification and profit maximisation. Buildings free areas in the central city zone are considered as unproductive and environmental, ecological and hygienic aspects are missing. This unambiguously points out the need to reconsider our perception of urban space potential and specific needs of urban environment, mainly from the perspective of its sustainability.

Conclusion

In this paper we have not intended to substitute, but to enrich planning processes and to move them towards the higher objectification, controllability and operationality in the cases, when input conditions or end users requirements change. Proposed procedure should be understood as open model, not a final solution. The choice of methodology and designing the decision scheme strongly depends on both input data and end-user requirements, which dynamically change in time and space.

Such nature of decision process could make management of living environment and its optimisation more attractive for city habitants. We see the highest potential for the employment of these principles at the city peripheries, in the spacious prefab housing estates with low quality of environment.

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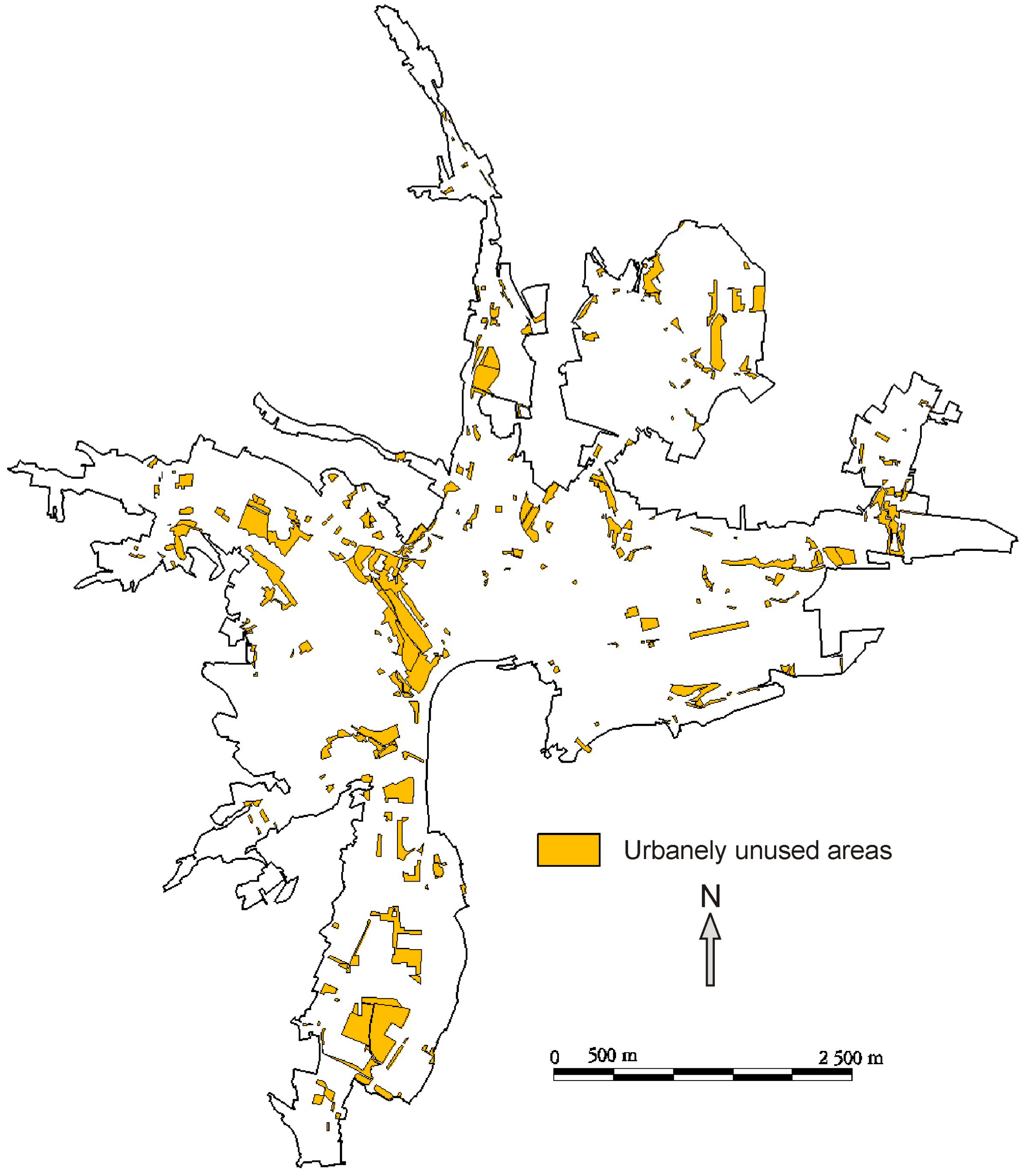
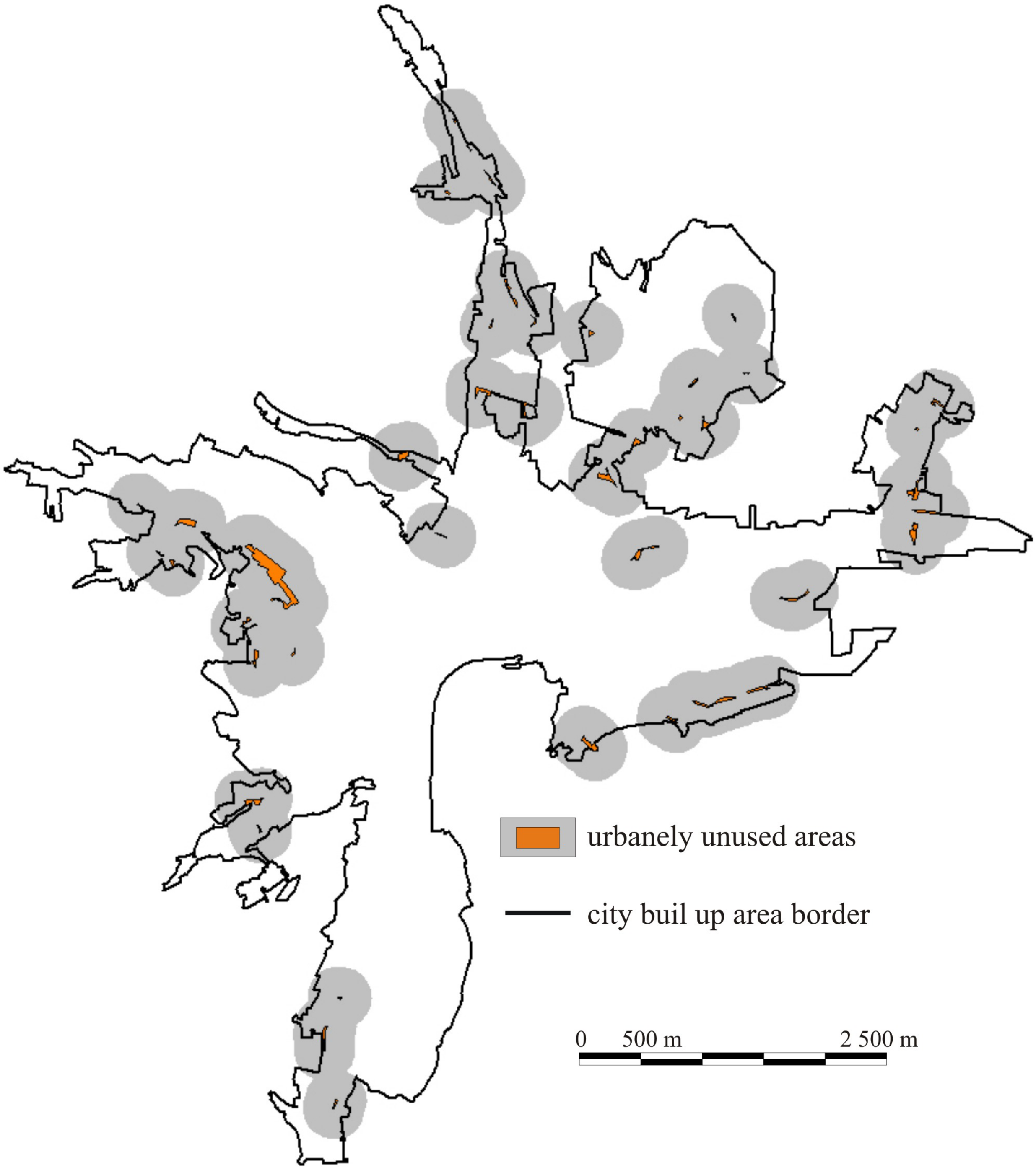
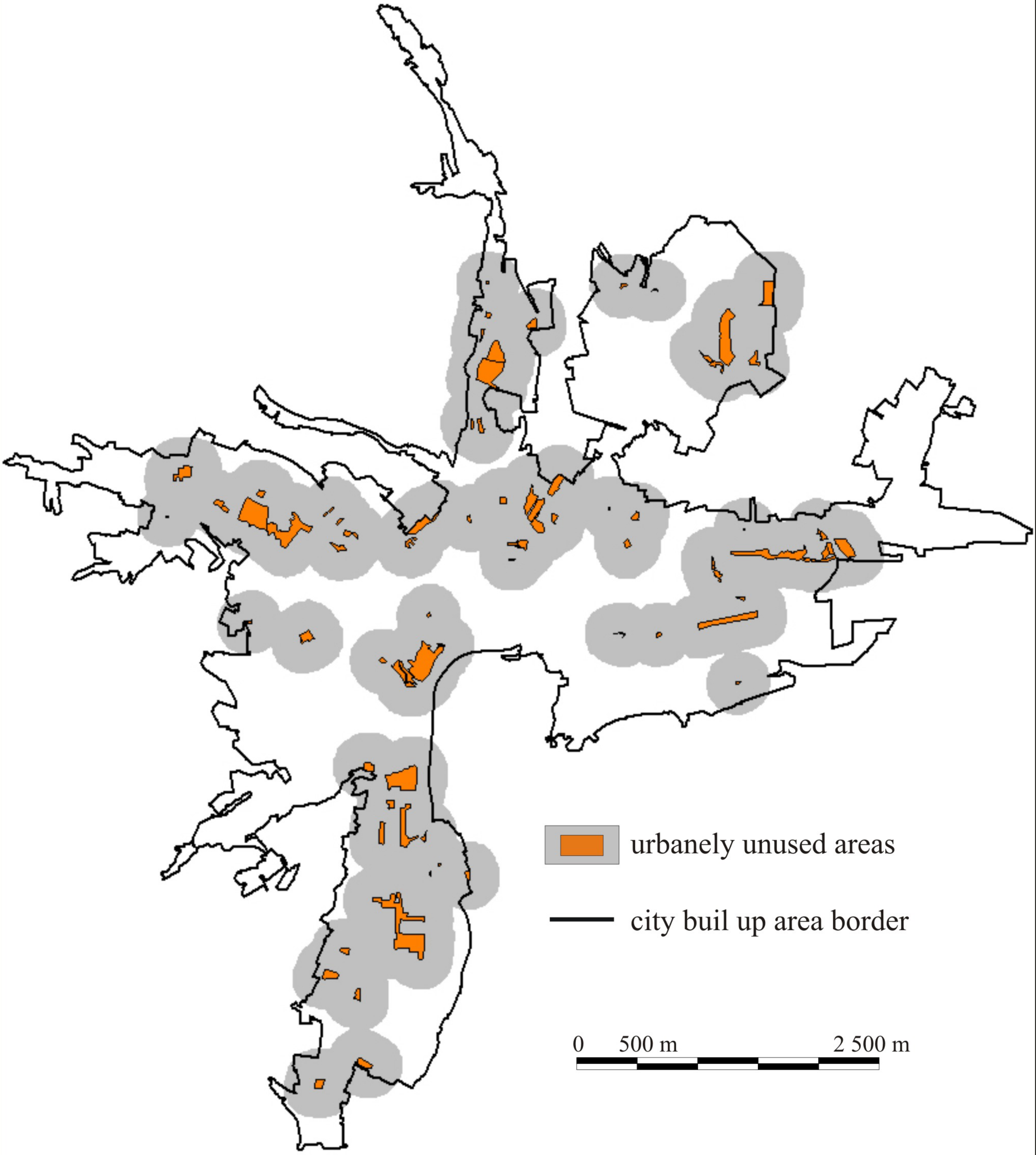
Annex 1.
Banská Bystrica city - Urbanely unused areas spatial distribution

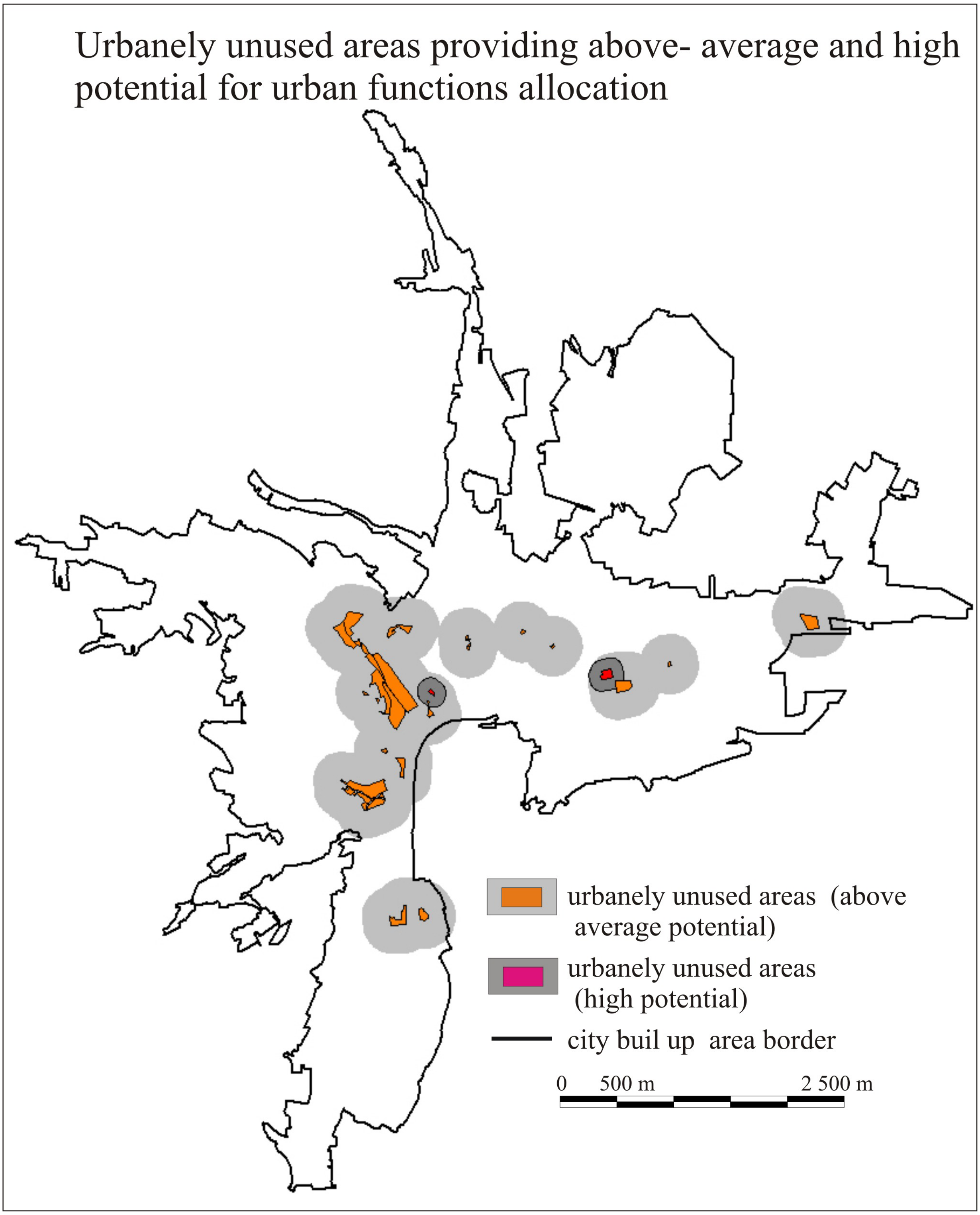


Urbanely unused areas providing low potential for urban functions allocation



Urbanely unused areas providing average potential for urban functions allocation




Urbanely unused areas providing above- average and high potential for urban functions allocation
urbanely unused areas (above average potential)
urbanely unused areas (high potential)
city buil up area border
0
500 m
2 500 m