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Research paper

Geodata influencing land market and sustainable development

Rimvydas Gaudesius

National Land Service under the Ministry of Agriculture, Gedimino pr. 19, Vilnius, Lithuania
Vytautas Magnus University, K.Donelaičio g. 58, Kaunas, Lithuania
e-mail: rimvydas.gaudesius@nzt.lt

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Abstract: The suitability of a land plot in a real estate market could be identified as a good investment because the land plot is deemed as popular. This activity is important for economic growth, who is one of the sustainable development goals. Mostly, all research in this field is focused on sustainability as well as the opinions of professionals. However, this field should be explored from another side which is based on real geodata. Criteria and its weight are very important in decision support systems. The correct criteria can help in selection of the best real estate object for an investment, but it is not only useful but also and a challenging task that has not yet been solved. The methods of research are data graphical analysis, correlation, decision supporting systems, etc. The research aims at determining the significance of the connections and using them as the criteria in the selected decision supporting method. In addition, it will be determined which decision supporting method defines the most suitable object for investment. These new criteria are proposed for operation in the land use models. Furthermore, it has been identified as one criterion, which is significant in the urban and agrarian territories. Also it turned out, that the land plot is the most active when it is as far from a densely built-up residential territory as possible and as close to a school, and when the land plot is as large as possible.

Keywords: land management, sustainable development, land plot, decision support system, criteria

1. Introduction

Not all areas are attractive for residential development. For this reason, scientists are trying to assess territories under various criteria in order assess suitability. Kulakov (2018) has analyzed various development projects and tried to identify which objects promote activity and which part of the investment should be provided by private investors and which by state. In particular, it is emphasized that mutual fund has to be developed for utilization of infrastructure and to encourage social welfare buildings. Authors identify a number of approaches assessing the following areas of this segment as demand, investor financial capacity, supply, and income opportunity. It has been suggested to use the income criterion more actively because the area is attractive for development when the investment pays off. Besides, the authors state that the purpose of the land, the possibility of commercial opportunity, etc. are very important (Kulakov and Baronin, 2017). Currently, researches on criteria of sustainable houses are very popular. The criteria determining the attractiveness of residential buildings are house price, house size, and distance to hospital, distance to work, electricity supply, security, and distance to the educational institution. However, all of these studies are based on experts' opinion and the survey assessing the importance of these criteria (Said et al., 2016; Roshanfekr et al., 2016; Mulliner et al., 2011).

The Law on Land of RL (Lithuanian..., 1994) describes the terms of land use, i.e. duties of landowners and other users, special terms of use, servitudes as well as the procedure of determination and changing the principal purpose of the use of land. Regarding the different special terms of land use restrict activities differently (Lithuanian..., 1992). For example, a land plot having more restrictions and a larger area in which they are applied will be less active. However, engineering networks located close to a land plot in a town/city may be considered as a positive feature. Active land plot means, that it is very popular in real estate market, because it was resold many times.

The characteristics of land plots influencing activeness of the land market have the impact on the land market value as well. Land plots are normally evaluated using the comparison approach which is based on the comparison and calculations, i.e. the value of the property, and it is determined by comparing the prices of market transactions in analogous objects taking into account small physical differences of the subject property and its analogues. When evaluating the real estate, the analogous property is considered to be objects which are identical to the object being evaluated in all their characteristics or the differences of the characteristics. (Tumelionis, 2013).

The following factors determine the differences in physical characteristics and terms of use of land plots:

– configuration of the land plot and convenience to perform agricultural works;
– restrictions in the usage, management and disposal of the land and land servitudes;
– the territorial layout of a land plot in respect to the requirements necessary for the owner of the land plot;
– engineering infrastructure and proposed improvement of a land plot;
– possibility to use a land plot for another activity (e.g. construction or recreation);
– productivity or relative fertility of agricultural lands (Čepulis et al., 2013).

Using the correlation method in 2015 it was determined that the relationship between the characteristics of land plots and activity in the real estate market in an agrarian territory are arranged by their significance as follows. Starting from the strongest one these are distance to a road, distance to a town/city, area of the land plot, possibility to change the purpose of what number of established restrictions, configuration of the land plot, and productivity score (Gaudėšius et al., 2015). However, these relationships are likely to be different in urban territory.

Aiming for the most efficient (maximum) and best use of a land plot, most land plots located in towns/cities and suburbs are transferred to persons planning to use them for urban development. The scientists, in analyzing this process, notice that "spot" territorial planning and rapid growth of urbanized territories affect the landscape of towns/cities and villages and increase the need for public infrastructure, consumption of natural and energy resources as well as ecological pollution (Laurinavičius and Galinienė, 2011). Thus, the real estate market influences not only economic growth but also social and environmental factors.

The most efficient use of land plots can be determined by applying a general plan stipulating the measures for long-term territorial management as well as the following analytical calculations. One of the calculation methods recommended for the optimization of prospective use of land plots is the multi-criteria assessment method applicable in real estate analysis (Malienė et al., 1999). Such methods are very popular not only in land usage planning (Bunyan et al., 2019; Cai et al., 2019; Guarini et al., 2016; Rose et al., 2016; Hallstedt, 2015; Mosadeghi et al., 2015; Zhang et al., 2012).

Most of these methods do not do without an expert evaluation of the criteria, which sometimes becomes complicated and biased. TOPSIS and SAW mathematical methods (decision support system) are selected because they are different in calculation and can be used without expert assessment.

The TOPSIS method was introduced by Hwang CL., Yoon K. in 1981. The main idea is an alternative which is at the shortest distance to the ideal selection and the longest distance to the poorest one (formulas (6)–(11)). This method is highly universal due to its capacity in usage of data of different types. Therefore, it is applicable in various fields such as mechanical engineering, medicine, computer science, management, etc. (Markovic, 2010; Saraff et al., 2013; Soufi et al., 2015; Karim and Karmaker, 2016; Leń et al., 2019; Oktaviana et al., 2019; Kacprzak, 2019).

The SAW method is one of the longest used ones. It is calculated in the simplest way. Thus, it is one of the most popular multi-criteria decision supporting methods. Anticipated averages are used in calculations as respective value is given to each alternative (formulas (12)–(14)). Since this method is one of the oldest ones, many modifications have been proposed aiming at correcting of the shortcomings discovered. The SAW modifications were used in this calculation (Memariani et al., 2009; Afshari et al., 2010; Podvezko, 2011; Salehi et al., 2014; Karlitasari et al., 2017).

Multi-criteria decision supporting methods are compared by using analysis of sensitivity when the number of criteria or its' weights are changed. In this way it is shown what criteria is the most important and which method is more stable for changes (Malienė et al., 2018; Mulliner et al., 2016).

Each investor analyses the market before purchasing real estate. The objective of the analysis is to minimize the risk and to maximize the opportunities. The environment suitable for investments is created by favourable social, economic and political terms. However, one of the most important criteria of analysis is location of the real estate object (Čiegis et al., 2009; Bueno et al., 2016; Komisarov et al., 2016; Giudice et al., 2019; Tang et al., 2019). An active real estate market positively influences the general economic growth of the country. However, too intensive and reckless investing can cause an economic crisis (Hong, 2014; Huang et al., 2015; Dzikevičius et al., 2015; Krulický et al., 2019).

The articles do not demonstrate how to make calculations by using the multi-criteria decision supporting methods. Therefore, the minimum amount of information regarding the TOPSIS and SAW methods is presented and mainly the achieved results are shown. It is impossible to provide all detailed calculations due to large volume of data. The results are useful for land-usage models in which the criteria of sustainability have been used.

The object of this research is to propose criteria by analyzing the data of National Land Service under the Ministry of Agriculture (NLS) and State Enterprise Centre of Registers (CR). The result is achieved by employing the following goals. Firstly, by identifying relationships between the characteristics of a land plot (in respect of the location) and use of land plot in the real estate market, as well as by identifying their significance. The significance could be applied in the decision supporting methods aiming at prediction of the most active land plots in the real estate market in advance. Secondly, by using these relationships and geo objects, like the criteria for the land usage model and conducting the test aiming at selection of the land plot, the best one, for example for investments. Thirdly, by comparing which of the applied methods is better in usage.

The research is relevant because it complements the previously proposed criteria for sustainable development and the research method is unique because it is based on actual data not on the expert surveys which are used in most of the studies. In addition, significant multi-criteria analysis methods have been used.

2. Data and methods

A part of the territory (90 ha; 110 land plots) in Lithuania, in Klaipėda city has been selected for the research. The land plots selected for research are currently agricultural. However, it is planned to develop them by the residential houses being in the general plan of the city. The selected area is significant because there is a noticeable gap that involves uneven development between urban and district urbanization. The detailed land-use planning documents for these land plots are not completed, so the opportunities of its' usage are only determined by the general plan of the city where the construction of small residential houses is anticipated. Most of these plots have not been used under the set purpose. Consequently, the mature poor bushes detracted the urban landscape and became a place for to get rid of the waste.

The selected methods of research are data analysis, synthesis, induction, graphic analysis (using AutoCAD program), correlation analysis (using Excel program), abstraction theories, and decision supporting systems (TOPSIS and SAW methods). The data from NLS and CR have been used as well (of 26 year period from 1994 to 2019). The main data is information, providing the number of times the property has been transferred (number of buying and selling) to the relevant plot of land. This data has been collected manually.

SAW and TOPSIS methods have been selected for their reliability and long-term usage in another studies. These methods are actively used in current research as it is apparent from the latest scientific publications. These methods have been selected regarding the simpler calculation methodology helping to collect and describe data of considerable amount of land plots and much time spent for the research. It is also possible to determine the value of the set criteria instead of an expert survey.

Results of the criteria are used in the majority of multi-criteria decision supporting systems. They are usually determined by surveying experts, and then criteria are ranked by importance.

Different data and methods have been used in this research. The data of CR and NLS shows the location of the land plots being investigated and real information regarding the number of transfers of the land plots (Figure 1). The real data, not personal opinion, is used in this way as it is different and has some advantage.

Geo objects (the main road, existing built-up territories, etc.) are marked in the graphic map (Figure 2) and distances to them are defined as criteria in calculations.

In the first part, the correlation coefficient and determination coefficient are calculated in line with the formula (1). A linear regression equation is formed in line with the formulas ((2), (3), and (4)).

$$R = \frac{n\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right)}{\sqrt{\left[n\left(\sum x^2\right) - \left(\sum x\right)^2\right]\left[n\left(\sum y^2\right) - \left(\sum y\right)^2\right]}}, \tag{1}$$

$$Y = a + bx, \tag{2}$$

$$b = \frac{n\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right)}{n\left(\sum x^2\right) - \left(\sum x\right)^2}, \tag{3}$$

$$a = \frac{\sum y - b\sum x}{n}. \tag{4}$$

Here: R the correlation coefficient;

x and y – the values of the variable in a sample;

n – number of the pairs.

The following criteria are selected for the multi-criteria decision supporting method: distance from the land plot to recreational object (territory), distance to an existing (planned) fire department, an existing or planned teaching institution, an existing or planned street, an existing (planned) industrial object, existing high voltage and low voltage power lines, and existing residential territory as well as area of the land plot.

$$\sum_{W_i} = 1 \;\Rightarrow\; w_1 + w_2 + \ldots + w_n. \tag{5}$$

Here: W_n weight of criteria.

In the second part, calculations are performed further using the TOPSIS and SAW mathematical methods. Values are inserted into the matrix (6), distances from the land plots to respective geo objects (values of the criteria). Since it is aimed for the best result and the correlation has shown different dependence (positive and negative) the minimum values of some criteria and maximum values of another criterion are sought. All criteria and respective criteria values (7) are used in the first calculation. The sensitivity of the results is conducted later by reducing the number of the criteria and thus changing the criteria weights (5) in Table 1. Normalization is conducted (8) and distances to the best and to the worst result are calculated (9), (10). Finally, the most optimal results are calculated (11) and the ranking is conducted in Table 3.

$$DM = \begin{bmatrix} X_{11} & \cdots & X_{1m} \\ \vdots & \ddots & \vdots \\ X_{n1} & \cdots & X_{nm} \end{bmatrix}, \tag{6}$$

$$DM_w = \begin{bmatrix} X_{1_w 1_w} & \cdots & X_{1_w m_w} \\ \vdots & \ddots & \vdots \\ X_{n_w 1_w} & \cdots & X_{n_w m_w} \end{bmatrix}, \tag{7}$$

$$N_{n_w m_w} = \frac{X_{n_w m_w}}{\sqrt{\sum X^2_{n_w m_w}}}, \tag{8}$$

Table 1. Distribution of determination of criteria weights

Criterion No.	1	2	3	4	5	6	7	8	9
Description of the criterion	Distance to the existing residential territory	Distance to a recreational object (territory)	Distance to a planned fire department	Distance to a planned teaching institution	Distance to the existing (planned) main street	Distance to a planned industrial object	Distance to the existing high-voltage power line	Distance to the existing low-voltage power line	Area of the land plot
Correlation coefficient	+0.341	+0.086	+0.128	−0.243	+0.002	−0.002	+0.151	+0.180	+0.194
The aim of the SAW and TOPSIS method	Max	Max	Max	Min	Max	Min	Max	Max	Max
Weighted criterion (w)	0.256	0.065	0.096	0.183	0.002	0.002	0.114	0.136	0.146
Weighted criterion (w)	0.258	0.065	0.097	0.183	–	–	0.114	0.136	0.147
Weighted criterion (w)	0.276	–	0.103	0.196	–	–	0.122	0.146	0.157
Weighted criterion (w)	0.308	–	–	0.219	–	–	0.136	0.162	0.175
Weighted criterion (w)	0.356	–	–	0.254	–	–	–	0.188	0.202
Weighted criterion (w)	0.438	–	–	0.312	–	–	–	–	0.250

$$S_i^+ = \sqrt{\sum \left(N_{n_w m_w} - \max N_{n_w}\right)^2}, \tag{9}$$

$$S_i^- = \sqrt{\sum \left(N_{n_w m_w} - \min N_{n_w}\right)^2}, \tag{10}$$

$$DS_n = \frac{S_i^-}{\left(S_i^+ + S_i^-\right)}. \tag{11}$$

Here: X_{nm} values of alternatives;

$X_{n_w m_w}$ normalizated values of alternatives;

S_i^+ and S_i^- – distances between results of alternatives.

The SAW mathematical method is simpler and the matrix with initial values, formed before, is normalized (12), (13). First of all, multiplication by respective criteria weights (14) is conducted in the next step only and thus, final values are obtained. Finally, the ranking is conducted in Table 2, and the best selection is determined.

$$N_{nm}^+ = \frac{X_{nm}}{\max X_n}, \tag{12}$$

$$N_{nm}^- = \frac{\min X_n}{X_{nm}}, \tag{13}$$

$$DS_n = \sum W_i N_{nm}. \tag{14}$$

Here: N_{nm} normalizated values of alternatives;

DS_n – calculated results with weights of criteria.

Ultimately, the mathematical methods show which land plots are most active (Figure 3). All these land plots may be offered as a good investment.

3. Results

Correlation coefficients were obtained after calculations of graphics by the arrangement of the land plots in the space and determination of the distances between the existing and planned objects (relationships between the selected criteria and number of sales). Contrary to the previous research (in the agrarian territory), the correlation coefficients are very weak (0.002–0.341) in the urbanized administrative location. It can be statistically maintained that there is no correlation between the selected criteria at all. The mathematical models used will show that selected criteria can be used for the most optimal choice (investment) and forecasts.

In order to find which method is the most appropriate to use and how much, (which one), of the selected criteria have a greater significance for the end of the result; three challenges have been selected for sensitivity. First of all, it is important to find out how reliable the method is and to choose the best option, (the most active plot of land). Secondly, what is the numerical difference between the best option proposed by the method

Table 2. The results (ranking). Arrangement of land plot by priority after calculations

SAW method											
9 criteria		7 criteria		6 criteria		5 criteria		4 criteria		3 criteria	
Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score
13	0.597835	13	0.600157	13	0.6336747	13	0.5920332	13	0.6636204	13	0.7572243
12	0.573065	12	0.575280	12	0.5727513	11	0.5437148	12	0.5887436	11	0.5595053
11	0.564932	11	0.567373	11	0.5565478	12	0.5423807	11	0.5887000	9	0.5369913
19	0.508325	19	0.510396	19	0.5187172	19	0.5015216	9	0.5191057	15	0.5322545
9	0.503337	9	0.503167	26	0.4994115	26	0.4806600	19	0.4793705	17	0.5069174
26	0.476788	26	0.477879	17	0.4793778	9	0.4499488	15	0.4438502	26	0.4980221
17	0.455772	20	0.456399	15	0.4731175	17	0.4390336	26	0.4342333	12	0.4935018
20	0.454491	17	0.456003	9	0.4722606	20	0.4327928	20	0.4253130	19	0.4491486
15	0.448166	15	0.450287	20	0.4569796	25	0.4182420	17	0.4136116	20	0.4217876
25	0.428555	25	0.429193	25	0.4434945	15	0.4128775	10	0.3593671	16	0.4210219
18	0.419511	18	0.420876	18	0.4383282	18	0.4119409	25	0.3567484	25	0.3966002
10	0.403265	10	0.404613	16	0.4165361	30	0.3745446	16	0.3562063	10	0.3822441
16	0.392058	16	0.39371	14	0.3908247	16	0.3497649	18	0.3381292	14	0.3718000
21	0.385275	21	0.386695	30	0.3872387	10	0.3454206	14	0.3279571	21	0.3154421
14	0.382514	14	0.384214	10	0.3784095	21	0.3367639	21	0.3048188	18	0.3144884
30	0.364608	30	0.365888	21	0.3707622	14	0.3208894	30	0.2759046	30	0.3043082
23	0.283483	23	0.282858	28	0.2629657	28	0.2357387	8	0.2101091	8	0.2409155
22	0.279769	22	0.280101	29	0.257919	29	0.2301232	28	0.1463804	1	0.1601084
8	0.278159	8	0.278422	27	0.2571892	27	0.2292999	22	0.1396119	7	0.1523969
28	0.267236	28	0.267751	23	0.2558345	23	0.2086953	23	0.1393089	28	0.1472727
27	0.261868	27	0.262340	22	0.2529066	22	0.2054344	27	0.1376065	23	0.1443609
29	0.25533	29	0.255807	8	0.2279271	8	0.1967754	29	0.1358603	22	0.1416582
24	0.230653	24	0.229639	24	0.2028722	24	0.1688206	1	0.1321652	29	0.1372744
4	0.196406	4	0.196697	4	0.1831718	4	0.1660300	7	0.1259068	27	0.1364139
5	0.180554	5	0.180403	1	0.1650299	5	0.1529408	4	0.1087022	4	0.1307301
3	0.162327	3	0.162426	5	0.1542865	1	0.1457505	24	0.0931976	24	0.1026045
1	0.157687	1	0.158173	7	0.1523271	3	0.1251228	5	0.0774615	5	0.0922925
7	0.153212	7	0.153649	3	0.1465099	2	0.1190514	6	0.0684552	6	0.0812443
2	0.149992	2	0.150125	2	0.1410679	7	0.1124464	2	0.0678204	2	0.0804408
6	0.131297	6	0.131400	6	0.1248882	6	0.1010111	3	0.0667891	3	0.0791430
would be the best choice (6–10 transfers)				would be the normal choice (3–5 transfers)				would be the worst choice (0-2 transfers)			

Table 3. The results (ranking). Arrangement of land plot by priority after calculations

TOPSIS method											
9 criteria		7 criteria		6 criteria		5 criteria		4 criteria		3 criteria	
Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score	Land plot No.	Estimated score
11	0.6554875	11	0.6561584	11	0.6555477	11	0.6563157	11	0.6776597	11	0.6698527
12	0.6253204	12	0.6255533	12	0.6265063	12	0.6274920	12	0.6471622	9	0.6161346
19	0.5737497	19	0.5740124	19	0.5787509	19	0.5782980	9	0.5785358	12	0.5755743
9	0.5575113	9	0.5586611	9	0.5530361	9	0.5526380	19	0.5752690	19	0.5658299
20	0.4967071	20	0.4970764	20	0.4986742	20	0.4969474	20	0.4980009	20	0.5185639
13	0.3992903	13	0.4004506	13	0.4043506	13	0.3968505	13	0.4058444	13	0.4415848
18	0.3637676	18	0.3633458	18	0.3671824	18	0.3623998	7	0.3455164	7	0.3926566
21	0.3557922	21	0.3558087	21	0.3502441	21	0.3450898	21	0.3335937	15	0.3793183
7	0.3370603	7	0.3361904	7	0.3384013	7	0.3374465	15	0.3304293	21	0.3585643
10	0.3347831	15	0.3355750	15	0.3379195	30	0.3331477	18	0.3273036	17	0.3570510
15	0.3346445	10	0.3354051	30	0.3349138	15	0.3271163	10	0.3213834	1	0.3460853
30	0.330787	30	0.3312012	17	0.3268475	17	0.3192271	14	0.3123717	14	0.3426057
17	0.3237618	17	0.3244838	10	0.3242774	10	0.3184473	17	0.3052748	30	0.3418179
14	0.3217154	14	0.3221973	14	0.3226137	14	0.3114509	1	0.3020377	10	0.3411683
1	0.2971356	1	0.2963590	1	0.2992522	1	0.2992528	30	0.2852150	6	0.2952839
16	0.2646670	16	0.2653527	16	0.2674265	6	0.2610661	6	0.2599831	18	0.2905996
6	0.2610192	6	0.2600939	6	0.2612151	2	0.2493667	16	0.2454500	16	0.2789764
2	0.2502965	2	0.2493889	2	0.2496335	16	0.2484203	2	0.2407662	2	0.2738610
23	0.2437410	23	0.2431131	26	0.2405590	4	0.2357170	3	0.2205402	4	0.2523043
4	0.2391633	26	0.2390455	4	0.2362118	3	0.2341912	4	0.2175977	3	0.2511306
26	0.2389997	4	0.2384593	3	0.2345991	26	0.2315774	8	0.1869325	8	0.2136877
3	0.2375006	3	0.2366274	23	0.2317107	28	0.2230132	23	0.1860156	5	0.2047867
28	0.2289618	28	0.2282600	28	0.2269641	23	0.2225482	5	0.1790806	23	0.2044324
22	0.2280174	22	0.2274849	29	0.2246299	29	0.2206865	26	0.1761345	26	0.1850585
27	0.2260798	27	0.2253454	27	0.2240113	27	0.2200075	22	0.1653462	22	0.1769624
8	0.2250175	8	0.2248645	22	0.2147629	5	0.2109605	28	0.1647367	28	0.1729963
29	0.2247006	29	0.223982	5	0.2105215	22	0.2042566	27	0.1588865	29	0.1662287
5	0.2189018	5	0.2180777	25	0.1962980	25	0.1852756	29	0.1569294	27	0.1656944
24	0.1992709	24	0.1985630	8	0.1895524	8	0.1837660	24	0.1349057	24	0.1519412
25	0.1965977	25	0.1961661	24	0.1870162	24	0.1820115	25	0.0987249	25	0.0649321
would be the best choice (6–10 transfers)				would be the normal choice (3–5 transfers)				would be the worst choice (0–2 transfers)			

and the more realistic best option? Finally, what is the numerical difference between the best option proposed by the method and the worst option.

Evaluating the results of the SAW method, it is shown (Table 2) that land plot No. 13 should be the best selection but in reality it is not the most active land plot. This result is suggested when selecting by three criteria (0.7572243) and the least guaranteed result when using five criteria (0.5920332). The second proposed option is usually the plot of land No. 12 and land plot No. 11. Land plot No. 12 is very active, so it was expected that the method would propose this option. The results showed that the numerical value between the proposed plot of land and the most active plot of a land is the lowest when nine criteria (0.02477) are used and the highest when three criteria are used (0.220233). It is also relevant to calculate the numerical value (difference) between the best option proposed by the method and least active plot of land. The minimum difference arises when nine criteria are used (0.08951) and maximum difference is when three criteria are used (0.2559222). Evaluating the results of the TOPSIS method, it is shown (Table 3) that the land plot No. 11 should be the best choice but in reality it is not the most active land plot. This result is arguably suggested when selecting by four criteria (0, 6776597) and the least guaranteed result when using nine criteria is (0, 6554875).

Table 4. Value of criteria by selected best land plot

Criteria and possible meanings / meanings of the best selection (Land plot No.)	Distance to the existing residential territory (*0–550 m*)	Distance to a recreational object (territory) (*0–1100 m*)	Distance to a planned fire department (*0-3500 m*)	Distance to a planned teaching institution (*0–850 m*)	Distance to the existing (planned) main street (*0–1450 m*)	Distance to a planned industrial object (*0–1075 m*)	Distance to the existing high-voltage power line (*0–2290 m*)	Distance to the existing low-voltage power line (*0–680 m*)	Area of the land plot (*0.03–284 ha*)
9	450	850	2000	300	30	25	10	340	1.02
11	500	650	2000	400	10	225	300	550	0.93
12	400	550	2500	300	10	200	290	770	1.02
13	250	100	3000	50	10	200	160	200	2.55

The second proposed option is usually the plot of land No. 12 and onetime land plot No. 9 has been selected. Land plots No. 12 and No. 9 are very active. Thus, it should be anticipated that the method would offer one of these selections. The results showed that the numerical value between the proposed plot of land and the most active plot of land is the lowest when five criteria (0, 0288237) are used, and the highest value is when three criteria are used (0, 0537181). The numerical value (difference) between the best option proposed by the method and least active plot of the land has been also calcu-

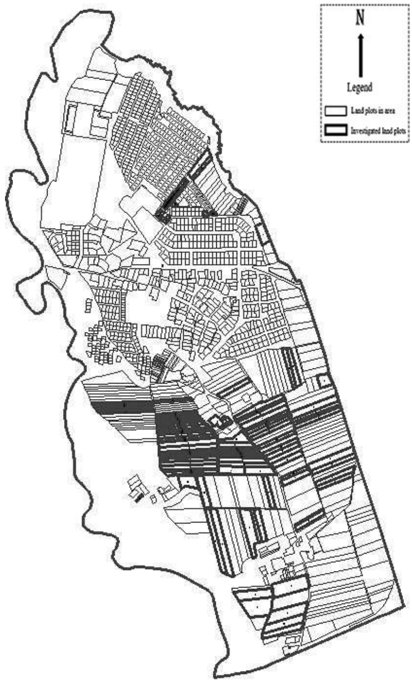

Fig. 1. Investigated land plots
(scale 1:25000)

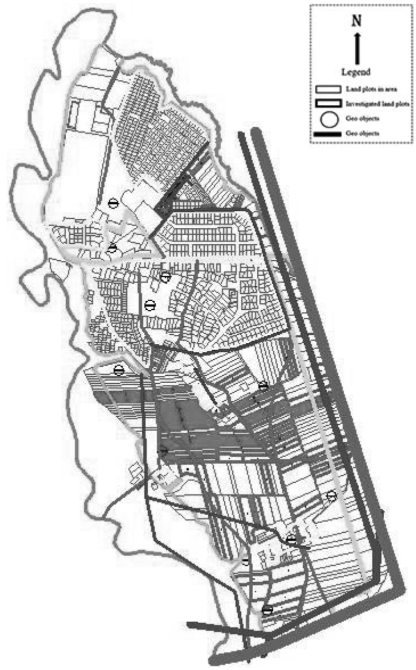

Fig. 2. The layout of geo-objects criteria
(scale 1:25000)

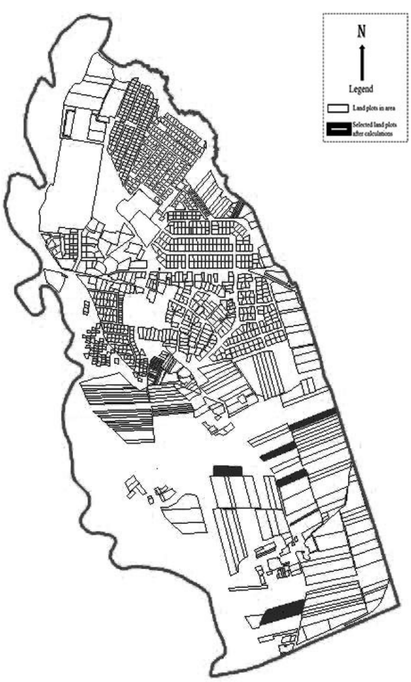

Fig. 3. Selected land plots after calculations (scale 1:25000)

lated. The minimum difference is when six criteria are used (0, 0767968) and maximum difference is when three criteria are used (0, 1040228).

4. Conclusions

The study is innovative and relevant because unique data (not expert opinion as in other authors' works but real cases) and popular mathematical methods are being used. Although, correlated relationships between the selected criteria and number of sales are very weak and it is (shown in) reference to the general results of the research. Investigated land plot located in the territory is the most active when it is as far from a densely built-up residential territory as possible and as close to a school when the area of the land plot is as large as possible. The following criteria influence activity in the real estate market in general, distance to industrial buildings, distance to the main street, and distance to a recreational object (territory). Thus, its shows that not all engineering and social objects (buildings), which were offered by another scientist, are so important for development. These factors are main results of research, and important for model of sustainable land usage.

Detailed descriptions of selected land plots under the selected criteria are shown in Table 4. Considering the fact that the selected criteria is sufficiently active in the marketplace it can be expected that they will to be built up by residential buildings in the near future. For this reason, the decline of the area of ??abandoned land will be visible in the urban area.

Using the SAW method, a group of the land plots which are the most passive in the real estate market, are distinguished clearly. The most active land plot is not ranked as the first. However, an averagely active land plot is ranked to be the first and it retains this position though a number of the criteria changes. The TOPSIS method, not group of the land plots which are the most passive, was outlined. The most active land plot was not ranked to be the first using this method either. However, three optimal selections, proposed using this method, include one of the most passive land plots which should be queried negatively. The TOPSIS method is less sensitive (0.0221722) to the number of criteria for the best selection than the SAW method (0.1651911). However, the SAW method provides a closer solution (0.02477) to the most active plot of land and reasonably greater difference to the least active (0.255922). Therefore, the SAW method corresponded to the forecast better between these compared methods. This result also is important, because mathematical principles of this method should be used in land model.

Mathematical calculations conducted in line with the SAW and TOPSIS methods reveal that the proposed criteria can be used as influencing the activity of land plots. When using the main three criteria, it is necessary to conduct further calculations using other mathematical models to select the most active (best) land plot in the real estate market thus naming the necessary method by the proposed criteria.

The only important criterion is an area of the land plot coinciding among the newly established criteria in the urbanized territory and the criteria that have been determined in an agrarian territory before further research. Using the following criteria, aims and criteria weights for further calculations in the territory planned to be urbanized are to be proposed. They are distance to a densely built-up residential territory (maximization (0.438)), distance to a school (minimization (0.312)), and area of the land plot (maximization (0.250). In addition, these criteria may be applied in the value of land plots in future research.

Acknowledgments

The research has now external founds.

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