Creating real estate maps by using GIS: A case study of Atakum-Samsun/Turkey

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Determining the real estate evaluations and reflecting them on taxations are among the most important economic resources of the developed countries. In Turkey, the system is not able to ground the real estate evaluations on scientific criteria yet, which causes various problems in applications regarding real estate evaluations (such as estate tax, expropriation, court surveillances) and an important economic loss. Thus, it is required to generate tax-base real estate evaluation maps within the scope of the legal legislation in Turkey. This study is aimed to generate a fast, up-to-date and dynamic evaluation map that would form a base for the real estate taxation. The closeness of real estates to the technical infrastructure and social equipment areas and their variety affect the real estate evaluations either positively or negatively and form the local benefit for real estates. This study determined the areas (such as main roads, green spaces, trading areas and urban attraction centers) affecting the evaluations of real estates depending on their positions. In order to make position-based decisions about the data being stored in the Geographical Information System, the geographical data were questioned and monitored by analyzes. The acquired data were exposed to necessary analyzes in the relevant modules of the GIS programs, which enabled us to grade the factors affecting the evaluation for each parcel and try to generate real estate evaluation maps depending on the evaluation-effect factors to be selected as dynamics. Parcel-based real estate evaluations were determined by imposing vector-based cadastral maps on these maps being generated. In this study, a raster real estate evaluation map was generated in unstructured parcels of a sample neighborhood via the scoring method and with the help of the Multi-Criteria Decision-Making Analysis and both environmental and social factors. This system enabled us to question and analyze the features of parcels and thus rapidly change them according to the system variables.

Keywords: *Real estate evaluation maps, multi-criteria decision making analysis, Geographical Information Systems (GIS), Land valuation*

1. Introduction

Real estate evaluation has become one of the most important economic issues of today due to the increasing need of quality structures and rearrangement of the real estate market. Having an increasing importance each day, the real estate evaluation is efficiently performed in a number of applications that may remarkably influence the national economy, such as partnerships, investments and funds based on real estates, credit and mortgage transactions within the scope of the housing finance, securitization of commercial real estates, generating funds in the real estate investment partnerships, generating pools in primary and secondary markets in banking, creating a resource by bringing the real estates of the treasury in economy, as well as privatization, nationalization, expropriation and the formation of estate tax evaluations.

Nowadays, there is a need for intense field works for each study to be conducted in the real estate evaluation sector, which has no data bank and this condition causes both time and cost losses and generally leads more than one evaluation experts to reach different values regarding the same real estate. For instance, determining a value for a real estate below or above the market quotation may cause both taxation irregularities in title deeds and municipalities and dishonored credits by banks. Grouping the data and information that are collected for any purpose under a common database will remarkably remove the repetitions of data collection and definitely decrease the cost of studies. In this context, it is apparently required to form a healthy database/system in the sector. Key notifications, reports and declarations published by international organizations like the Federation of International Cartographers (FIG), United Nations (UN), European Union (EU) and the World Bank (FIG,1995; UN, 1996; UNECE, 1996; Kaufmann and Steudler, 1998; UN and FIG, 1999; PCCEU, 2003; EU, 2004) primarily envisage the necessity for public authorities to develop systems where real estate market evaluations are determined and consequently provide the transparency of real estate markets (Çete and Yomralıoğlu, 2009).

These global needs compel the use of available technologies in studies concerning real estate evaluations. Being a new computer technology that does not have a long background but rapidly develops in the world, the GIS (Geographical Information Systems) is a system supporting the decision-makers in many fields. Today, the GIS software are commonly used in developing database systems in many fields like education, health, land administration, real estate, civil defense, military, banking, finance, economy, construction, cartography, urban planning, municipal work, public services, public safety, archeology, natural resources, transportation, logistics and communication (Nişancı, 2005). Applications (such as commercial property investments, real estate sector, land development) aimed at real estates that have an important place especially in national economies are

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efficiently used in the developed and developing countries. GIS could be defined as all the technical devices that enable us to collect, computerize, control, analyze and monitor the spatial and non-spatial information in the world for a certain goal (Tecim and Kıncal, 2004). GIS applications combine the accurate and up-to-date data and theory with practice. The integrated study, international standardization and data sharing provide a more effective and efficient use of GIS (Özten, 2009). It becomes more and more important each day to enable GIS to become integrated with different disciplines and share it for the public benefit.

In real estate evaluation studies, only an available data bank will prevent the time and cost losses that are encountered during the data collection method in the field, which is required for the evaluation, and determine the healthy real estate evaluations. Being a new computer technology that does not have a long history but rapidly being developed and improved in the world, the GIS (Geographical Information System), is a system supporting the decision-makers in many fields. Enabling the collection, storage and retention of both spatial and non-spatial data under a sole system, the GIS could meet the need for the sector to collect, keep, store and even share the required data in the studies concerning real estate evaluations (Wyatt, 1997; Yomralıoğlu, 1997a; Yomralıoğlu, 1997b; Yomralıoğlu and Döner; 2005).

2. Problem statement and aim of the study

Objective, accurate and reliable determination of real estate evaluations is important for the owners, vendors, purchasers of real estates and the social economy. Real estates comprise a large part of the social asset, and everyone desires to know the actual value of his or her real estates (Açlar and Çağdaş, 2002). In parallel with the developments in information technologies, the concept of Geographical Information Systems (GIS) has also started to be used in real estate evaluations in our country just like in many other countries during the recent years (Yalpir et al., 2014). In general terms, GIS is the product of hardware, software, and methods that are designed to solve the position-based complex planning, organization and management problems and carry out transactions like storing, processing, managing, modeling, analyzing, monitoring and printing the data about geographical spaces (Erdoğan and Güllü, 2004). The spread of GIS technology and increase of its usage by different disciplines have also increased the interdisciplinary cooperations. The determination of GIS-supported real estate evaluations will provide rapid, accurate and economic solutions in a number of transactions about real estates such as purchase-sale, renting, expropriation and taxation. GIS has an increasing importance in the determination of real estate evaluations due to the abundance of the data about positions and the variability of national economies. Establishment of the real estate evaluation system will enable the changes in the factors affecting the real estate evaluation and provide more accurate and useful values for purchase-sale values (Erdoğan and Tiryakioğlu, 2006).

The objective of this study is to generate the Real Estate Evaluation Maps for a sample neighborhood with the help of the Geographical Information Systems.

3. Material and method

Evaluation of unstructured parcels in urban areas is one of the most compelling problems of the real estate evaluation. Because even though it is possible to evaluate similar real estates being used for different purposes with the help of similar methods and criterion, they may show considerable differences. Accordingly, it is required to examine radically the real estate market for an objective evaluation (Deininger, 2003).

3.1. Multi-Criteria Decision Making Analysis

One of the main problems being encountered during the multi-criteria decision-making processes is the accurate determination of different preference grades, orders of importance and significance by considering many criteria for the choices being evaluated (Saaty, 1990). Four stages are used in the evaluation of real estates with the help of the Multi-Criteria Decision Making Analysis (MCDA) (Saaty, 1998):

Collect the current data about the real estates to be evaluated.

Determine the criteria to be used for the Multi-Criteria Decision Making.

Determine the values, significances, and units of the criteria for alternatives to be used in comparisons.

Generate a decision-making matrix. In this study, the significance was determined by that method (Yoon and Hwang, 1995).

3.2. Study Area

In order to generate a real estate evaluation map in unstructured parcels, a sample neighborhood was selected with the help of the scoring method, GIS technology integration, and the multi-criteria decision-making analysis. For instance, it was intended to determine the real estate evaluation maps of totally 45 parcels (28 unstructured and 17 structured) in Samsun Province, Atakum Neighborhood with the help of the Scoring Method and the Multi-Criteria Decision-Making Analysis. The parcels were integrated with GIS with the help of

the NetCad GIS method. It was primarily collected the up-to-date, accurate, reliable spatial and non-spatial data about these parcels. These data were in the vector and raster format. Graphic and non-graphic data were questioned in an integrated way.

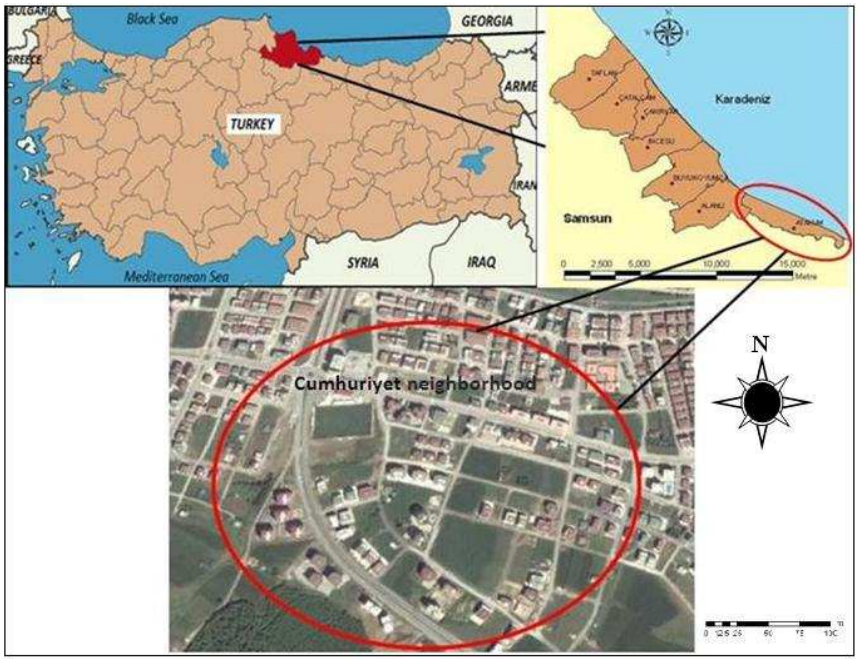

Fig. 1. Location of the study area.

In order to make position-based decisions about the data being stored in the Geographical Information System, the geographical data were questioned and monitored with analyzes. New data clusters were obtained by using the collected data in the spatial analyzes transactions. The pixel values of the factors affecting the parcel value were "valued" with the Scoring Method and the raster real estate evaluation map was generated with the significance of factors being determined.

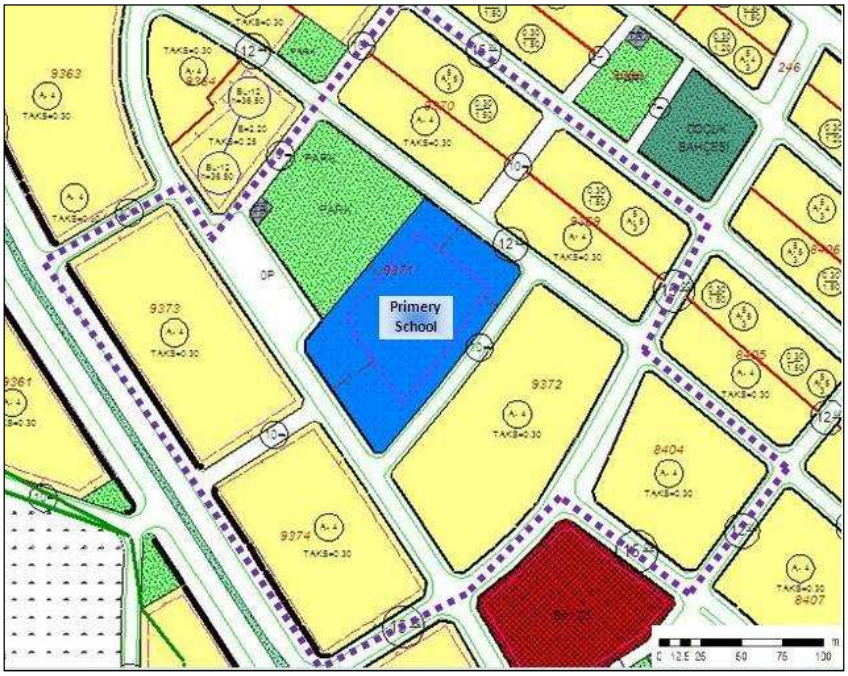

Fig. 2. A sample of the construction plan in the sample neighborhood where the application is carried out.

Table 1 shows the up-to-date, accurate, reliable spatial and non-spatial data about the aforementioned parcels.

Tab. 1. Factors affecting the real estate evaluations in the study field and the condition of parcels.

Plot No	**Parcel No**	**Area** [m²]	**Building ordinance**	**Building coverage ratio**	**Total construction site** [m²]	**Distance to the primary school**	**Distance to the park**	**Aspect to the road**	**Aspect**	**Benefiting from public services and infrastructures**
8404	1	1146.81	A-4	0.3	1376.17	104.48	204.59	70.85	Northwest	Available
	2	972.74	A-4	0.3	1459.10	136.86	241.34	25.67	North	Available
	3	952.30	A-4	0.3	1142.76	159.13	264.40	60.55	Northeast	Available
	4	982.34	A-4	0.3	1178.81	157.99	291.19	61.85	Southeast	Available
	5	969.96	A-4	0.3	1163.95	134.07	266.08	24.01	South	Available
	6	711.10	A-4	0.3	853.32	102.97	243.07	50.02	Southwest	Available
	7	789.16	A-4	0.3	1183.74	100.80	236.75	24.65	West	Available
9369	1	2091.66	A-4	0.3	2509.99	98.90	182.39	90.40	Northeast	Available
	2	1417.43	A-4	0.3	1700.92	82.78	194.35	39.17	East	Available
	3	2421.15	A-4	0.3	2905.38	94.31	207.21	103.12	Southeast	Available
	4	671.07	A-4	0.3	805.28	74.87	151.44	50.42	North West	Available
	5	485.69	A-4	0.3	582.82	64.95	149.99	14.57	West	Available
	6	780.89	A-4	0.3	1171.33	55.77	151.03	21.96	West	Available
	7	2558.47	A-4	0.3	3837.71	55.83	156.83	68.72	West	Available
	8	651.21	A-4	0.3	781.45	93.23	180.78	48.69	Southwest	Available
9370	1	2478.44	A-5	0.3	2974.13	198.43	100.06	106.09	Northwest	Available
	2	1006.24	A-5	0.3	1207.49	154.61	115.37	60.84	Northeast	Available
	3	564.30	A-4	0.3	677.16	119.00	79.37	48.58	Southeast	Available
	4	646.10	A-4	0.3	775.32	129.79	65.74	19.37	South	Available
	5	2251.20	A-4	0.3	2701.44	179.38	62.07	98.41	Southwest	Available
9372	1	1645.78	A-5	0.3	1974.93	143.06	131.74	80.23	Northwest	Available
	2	728.52	A-5	0.3	874.23	147.74	162.88	20.87	North	Available
	3	1038.62	A-5	0.3	1246.35	158.70	179.07	61.68	Northeast	Available
	4	841.63	A-4	0.3	1009.95	130.27	188.21	56.16	Southeast	Available
	5	430.80	A-4	0.3	516.96	117.86	154.24	14.00	South	Available
	6	500.58	A-4	0.3	750.87	115.44	131.65	16.00	South	Available
	7	569.19	A-4	0.3	683.02	109.67	119.93	17.84	South	Available
	8	871.62	A-4	0.3	1045.94	119.02	100.40	58.47	Southwest	Available
9373	1	384.41	A-4	0.3	461.29	357.73	249.56	46.68	Northwest	Available
	2	817.63	A-4	0.3	981.16	343.52	234.83	27.38	Northwest	Available
	3	3122.95	A-4	0.3	3747.54	319.05	211.64	114.62	Northwest	Available
	4	774.54	A-4	0.3	929.45	339.40	235.93	27.52	Southwest	Available
	5	620.57	A-4	0.3	744.69	317.32	214.43	23.81	South	Available
	6	467.88	A-4	0.3	561.46	296.69	204.68	15.88	South	Available
	7	594.07	A-4	0.3	712.88	288.21	195.34	19.99	South	Available
	8	702.56	A-4	0.3	843.07	264.13	167.74	18.71	North	Available
	9	590.36	A-4	0.3	708.432	273.62	184.45	20.42	South	Available
	10	793.01	A-4	0.3	951.62	246.79	150.20	56.25	Northeast	Available
	11	441.78	A-4	0.3	530.13	259.13	170.31	44.43	Southeast	Available
9374	1	457.98	A-4	0.3	549.58	233.89	156.39	44.82	Southwest	Available
	2	999.55	A-4	0.3	1199.46	212.21	127.39	62.35	Northwest	Available
	3	1993.03	A-4	0.3	2391.63	217.94	151.33	67.93	South	Available
	4	1740.68	A-4	0.3	2088.82	185.22	117.91	52.22	North	Available
	5	1491.08	A-4	0.3	1789.29	179.60	151.45	82.05	Southeast	Available
	6	1693.15	A-4	0.3	2031.78	153.16	119.38	70.85	Northeast	Available

4. Results and discussion

4.1. Factors affecting the parcels where real estate evaluation maps are generated by using the GIS integration, as well as their significances and analyzes

The criteria that would be important in the evaluations of parcels were determined and subsequently the significances were calculated by scoring these criteria according to the order of importance. Table 2 shows the relevant table.

Tab. 2. Factors affecting the real estate evaluations and their significance.

Criteria	Score	Significance [Point/∑]
Total construction site	10	0.256
Landscape and aspect	8	0.205
Distance to the primary school	6	0.154
Distance to the park	6	0.154
Frontal use	5	0.128
State of benefiting from public services	4	0.103
Total	39	

Table 3 shows the scores Obtained by the Parcels according to the Determined Criteria.

Tab. 3. Scores obtained by the parcels according to the determined criteria.

Plot No	Parcel No	Score of total construction site	Score of landscape-aspect	Score of distance to the primary school	Score of distance to the park	Score of frontal use	Score of the state of benefiting from public services	Weighted score
8404	1	3	8	8	4	6	10	773.29
	2	3	10	8	2	2	10	772.88
	3	3	9	7	2	5	10	772.90
	4	3	5	7	1	5	10	771.98
	5	3	3	8	2	2	10	771.44
	6	2	4	8	2	4	10	515.90
	7	2	6	8	3	2	10	516.21
9369	1	6	9	9	4	8	10	1541.90
	2	4	7	9	4	3	10	1028.85
	3	7	5	9	4	9	10	1797.21
	4	2	8	9	5	4	10	517.34
	5	2	6	9	6	1	10	516.70
	6	2	6	9	5	1	10	516.54
	7	7	6	9	5	6	10	1797.18
	8	2	4	9	4	4	10	516.36
9370	1	7	8	7	7	10	10	1798.11
	2	3	9	7	7	5	10	773.67
	3	2	5	8	8	4	10	517.03
	4	2	3	8	8	1	10	516.24
	5	6	4	7	8	9	10	1541.31
9372	1	5	8	8	6	7	10	1285.72
	2	2	10	8	5	1	10	517.21
	3	3	9	7	5	5	10	773.36
	4	3	5	8	4	5	10	772.54
	5	2	3	8	5	1	10	515.78
	6	2	3	8	6	1	10	515.93
	7	2	3	8	7	1	10	516.08
	8	3	4	8	7	5	10	772.80
9373	1	1	8	3	2	4	10	259.95
	2	3	8	4	3	2	10	772.00
	3	8	8	4	3	10	10	2053.03
	4	2	4	4	3	2	10	515.18
	5	2	3	4	3	1	10	514.85
	6	2	3	5	4	1	10	515.16
	7	2	3	5	4	1	10	515.16
	8	2	10	5	5	1	10	516.75
	9	2	3	5	4	1	10	515.16
	10	2	9	6	5	5	10	517.21
	11	2	5	5	5	4	10	516.11
9374	1	2	4	6	5	4	10	516.06
	2	3	8	6	6	5	10	773.16
	3	5	3	6	5	6	10	1284.11
	4	5	10	7	7	4	10	1285.75
	5	4	5	7	5	7	10	1028.80
	6	5	9	7	7	6	10	1285.80

4.1.1. Scoring and evaluating the criteria of the total construction site

Table 4 shows the scores obtained by the total calculated construction sites of parcels according to field intervals.

Tab. 4. Criteria and scoring of the total construction site.

Total construction site	
Field interval [m²]	**Score**
0-400	1
400-800	2
800-1200	3
1200-1600	4
1600-2000	5
2000-2400	6
2400-2800	7
2800-3200	8
3200-3600	9
3600-4000	10

In this analysis, the parcel that would take the largest construction site in a probable structuring was accepted as the parcel with the highest value according to the Parcel Areas Dimensions. The evaluation map was generated as in Figure 3. The factor significance of the shape and dimension of the parcel was taken as 0.256.

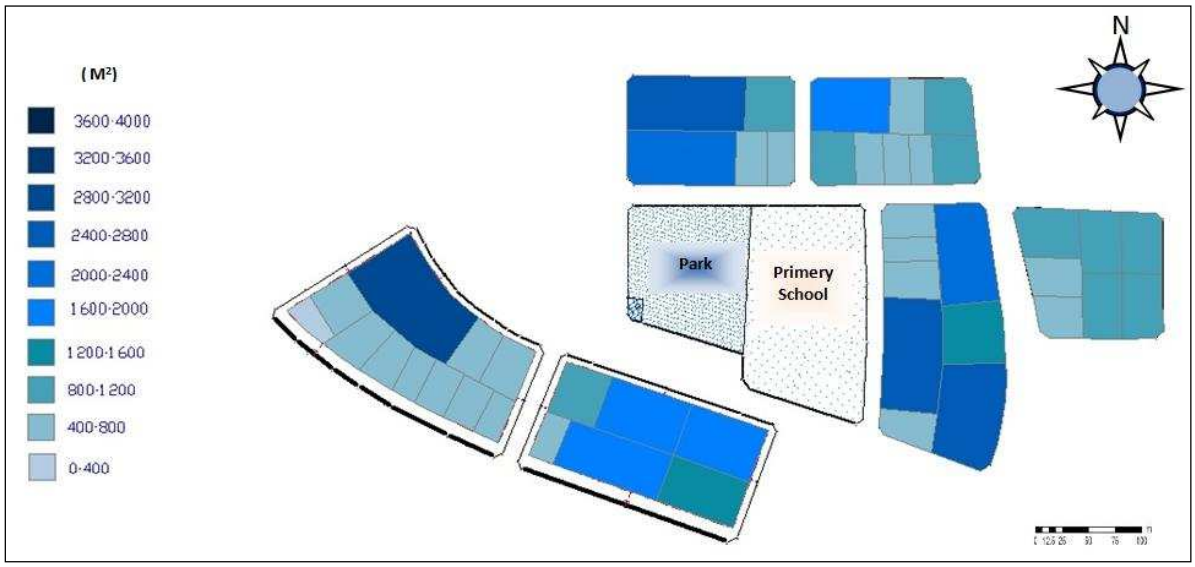

Fig. 3. Evaluation map of the "total construction site factor" after the implementation of the reclassification according to the scoring method.

4.1.2. Scoring and evaluating the criteria of landscape and aspect

Table 5 shows the scores obtained by parcels according to Landscapes and Aspects.

Tab. 5. Criteria and scoring of the landscape and aspect.

Landscape and aspect	
Value	**Score**
North	10
Northeast	9
Northwest	8
East	7
West	6
Southeast	5
Southwest	4
South	3

The North frontal of parcels was accepted as 10 points, and a score table was formed according to directions. The significance of the Landscape and Aspect was taken as 0.205. Figure 4 shows the evaluation map of the landscape-aspect.

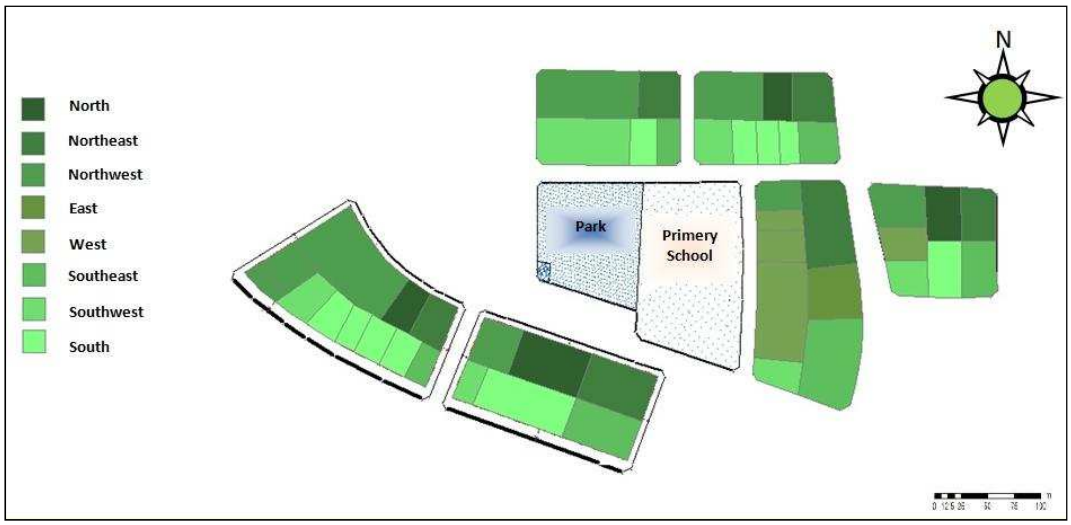

Fig. 4. Evaluation map of the "landscape-aspect factor" after the implementation of the reclassification according to the scoring method.

4.1.3. Scoring and evaluating the criteria of the distance to the primary school

Table 6 shows the scores obtained by parcels according to the distance to the primary school.

Tab. 6. Criteria and scoring of the distance to the primary school.

Distance to the primary school	
Range [m]	**Score**
0- 50	10
50-100	9
100-150	8
150-200	7
200-250	6
250-300	5
300-350	4
350-400	3

The evaluation map is shown in Figure 5. The significance of the Factor of the distance to the primary school was taken as 0.154.

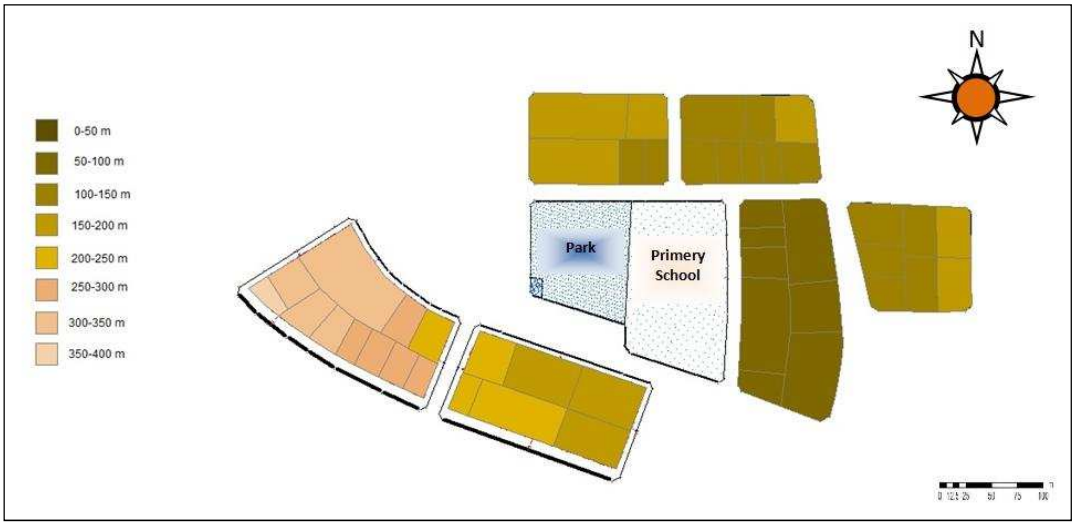

Fig. 5. Evaluation map of the "factor of the distance to the primary school" after the implementation of the reclassification according to the scoring method.

4.1.4. Scoring and Evaluating the Criteria of the Distance to the Park

Table 7 shows the scores obtained by parcels according to the distance to the park.

Tab. 7. Criteria and scoring of the distance to the park.

Distance to the park	
Range [m]	**Score**
0-30	10
30-60	9
60-90	8
90-120	7
120-150	6
150-180	5
180-210	4
210-240	3
240-270	2
270-300	1

The evaluation map is shown in Figure 6. The significance of the Factor of the distance to the park area was taken as 0.154.

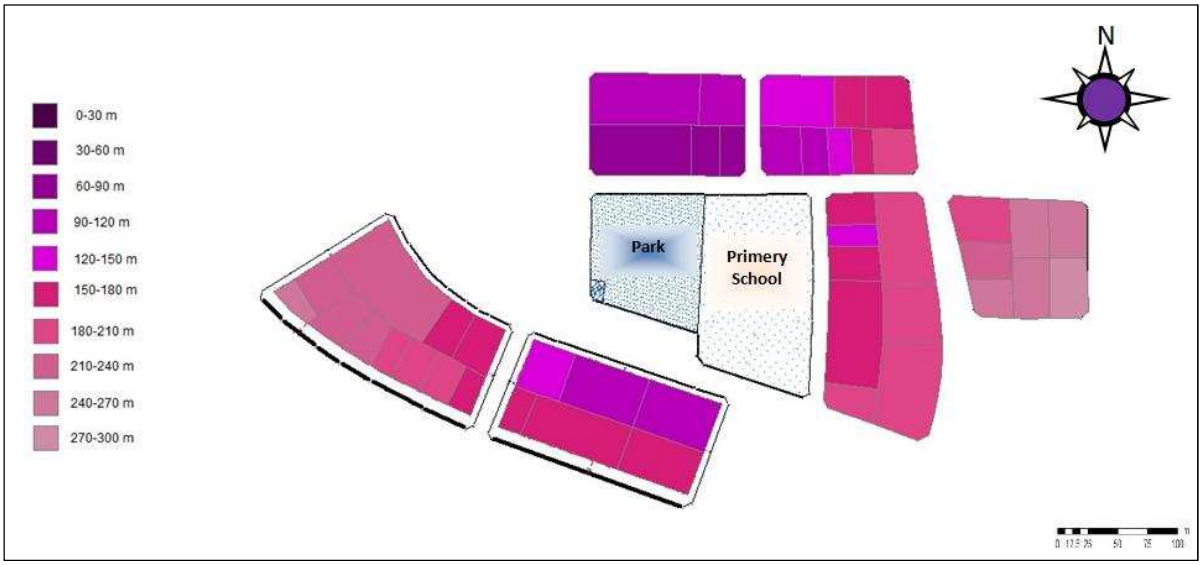

Fig. 6. Evaluation map of the "factor of the distance to the park" after the implementation of the reclassification according to the scoring method.

4.1.5. Scoring and Evaluating the Criteria of the Frontal Use

Table 8 shows the scores obtained by parcels according to the frontal use.

Tab. 8. Criteria and scoring of the frontal use.

Frontal use	
Range [m]	**Score**
14-24	1
24-34	2
34-44	3
44-54	4
54-64	5
64-74	6
74-84	7
84-94	8
94-104	9
104-114	10

In this analysis, the parcel with the longest frontal to the road in a probable structuring was accepted as the parcel with the highest value according to the Parcel Frontages. The evaluation map is shown in Figure 7. The factor significance of the Frontal Use Factor was taken as 0.128.

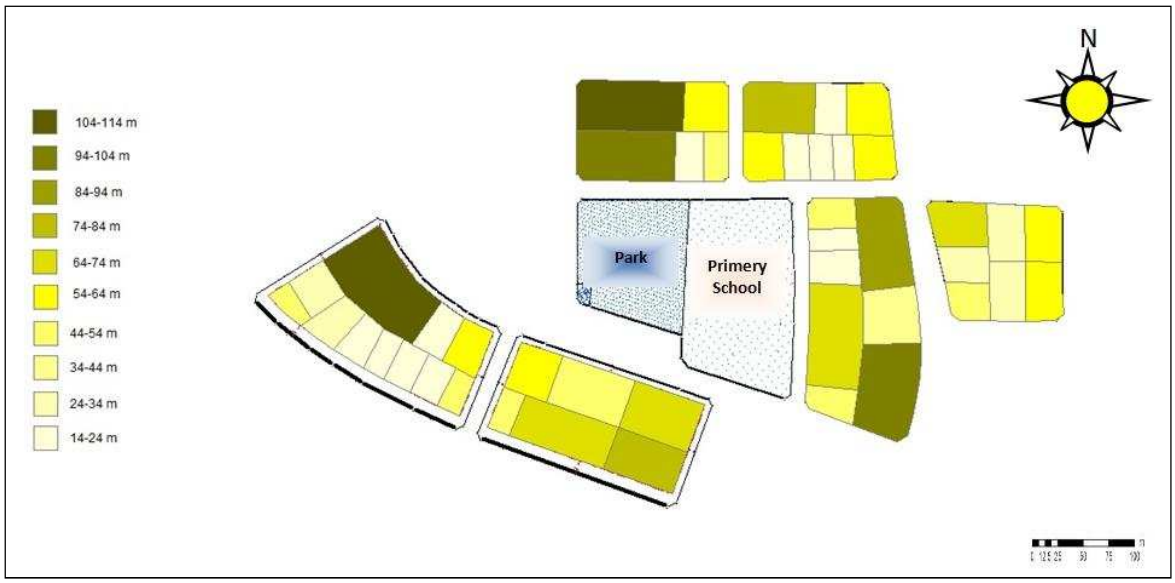

Fig. 7. Evaluation map of the "frontal use factor "after the implementation of the reclassification according to the scoring method.

4.1.6. Scoring and evaluating the criteria of benefiting from public services and infrastructures

The criteria of Benefiting from Public Services and Infrastructures was accepted equally for all parcels.

Tab. 9. Criteria and scoring of benefiting from public services and infrastructures.

State of benefiting from public services and infrastructures	
Value	**Score**
Available	10
None Available	0

The evaluation map is shown in Figure 8. The Factor of Benefiting from Public Services and Infrastructures was taken as 0.103.

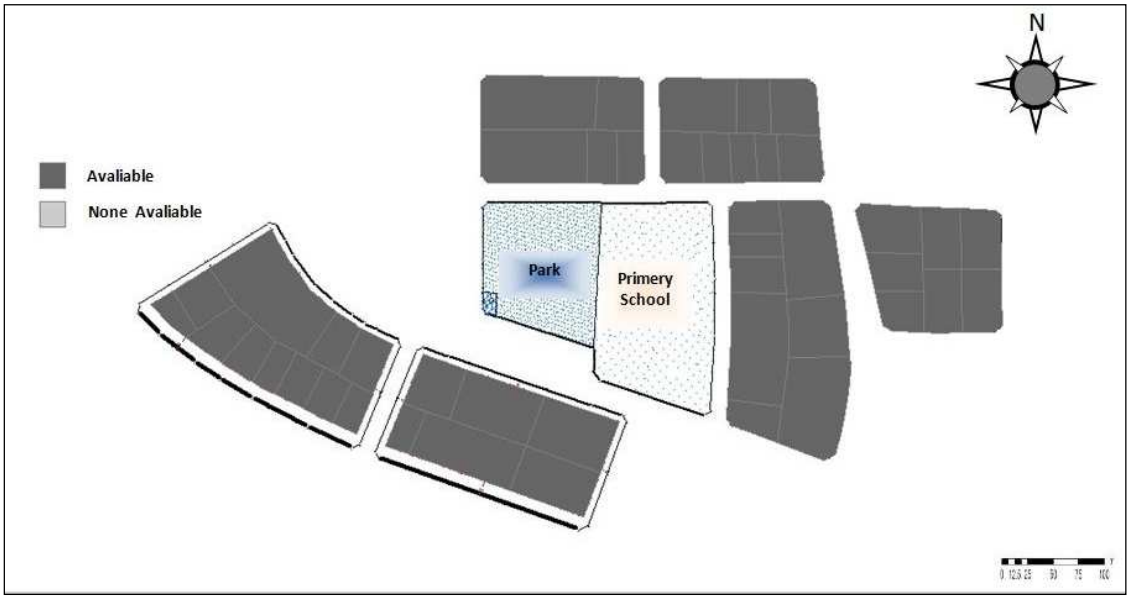

Fig. 8. *Evaluation map of the "factor of benefiting from public services" after the implementation of the reclassification according to the scoring method.*

As a result of the scoring criteria being indicated, the total values of the model neighborhood were separated into 10. The colors here correspond to the determined range.

As a result of the GIS analyzes that were conducted in consequence of the data being transferred to the database, the real estate evaluation maps of 45 parcels in the sample region were generated as in Figure 9.

Weighted Parcel Index Calculation= [(Total Score of Construction Site x 0.256) + (Landscape-Aspect Score x 0.205) + (Score of the Distance to the Primary School x 0.154) + (Score of the Distance to the Park x 0.154) + (Score of the Frontal Use x 0.128) + (Score of Benefiting from Public Services x 0.103)] / 6

Value scores of parcels and their correlations were calculated via **100**.

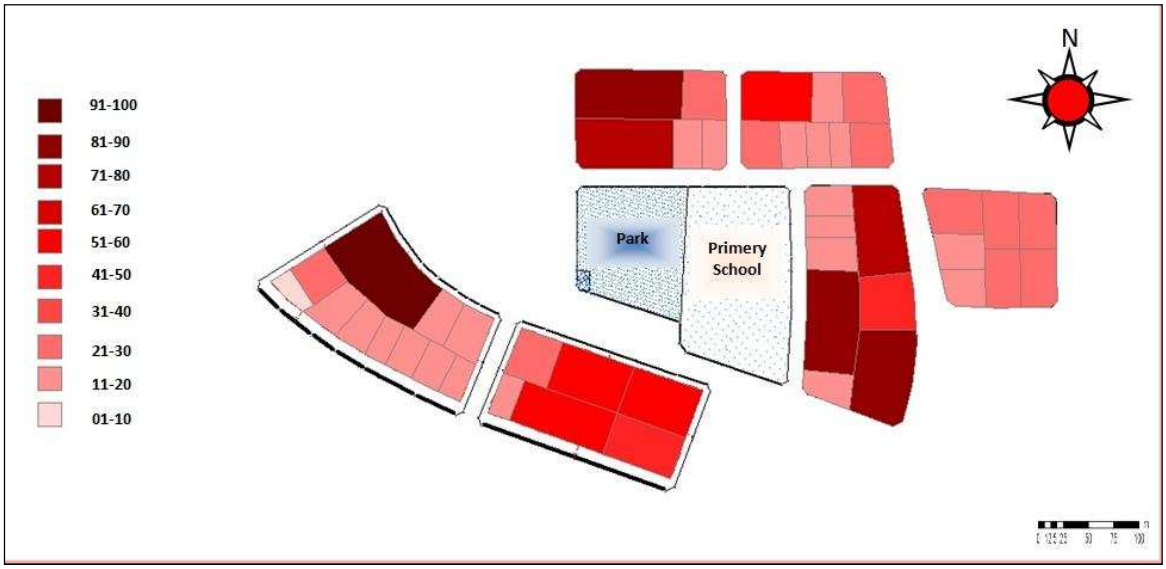

Fig. 9. Evaluation map being generated with the help of factor significances after the implementation of the reclassification according to the scoring method.

5. Conclusions

Real estate evaluation is a very important profession that is applied for public needs such as tax calculations, expropriation, privatization, nationalization, land arrangements, as well as private sector requirements such as insurance business and banking. The availability of the GIS technology in different disciplines provides updatable, accessible and analyzable solution opportunities based on a fast, accurate and efficient decision-making process in determining the values of real estates. This study determined the significance of the criteria being used in real estate evaluations with the help of the Multi-Criteria Decision Making Analysis and performed an evaluation by considering the effects of real estates upon their evaluations. The factors affecting the real estate evaluation vary according to the local traits; however, it is not possible to precisely define a model due to the variation of factors.

In this study, a raster real estate evaluation map was generated in unstructured parcels of a sample neighborhood via the scoring method and with the help of the Multi-Criteria Decision-Making Analysis and both environmental and social factors. A scoring was performed with the Scoring Method by considering the structuring terms that were assumed to be generated by unstructured parcels in the future according to environmental and social factors and the total score reflects the real estate evaluation of that parcel in terms of unit. This system could enable us to question and analyze the features of parcels and thus, rapidly change them according to the system variables.

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