FORECASTING RESIDENTIAL REAL ESTATE VALUES WITH AHP METHOD AND INTEGRATED GIS

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Abstract

Real estate valuation is an important subject which has to be studied carefully as there are a lot of individual subjective criterias. In this study Analytic Hierarchy Process (AHP), which is one of the Multi-Criteria Decision Analysis (MCDA) methods, is used to reproduce coefficients which would base for real estate valuation.

In this study; as traditional valuation methods are inadequate, residential real estate value and the model are developed to forecast the values of real estate with AHP. The analysis of values obtained from the model and values in market conditions are performed. At the same time, these values are integrated into Geographic Information Systems (GIS). Thus, a system is designed for creating the desired residential real estate value assessment.

Selcuklu district in Konya/Turkey is determined as the study area. 70 residential real estate of the 50 reconstruction islands are selected in the region. AHP model is divided into two buildings in which the first location attributes to areas including school, shopping center, sanctuary, healthcare organization, bus terminal and transportation network in the region of the reconstruction islands and the second the part attributes to structural areas (age, area, according to the sun position, floor condition, warming methods, security and parking situation of residential real estate). In order to determine the comparatively calculated model performance, the average approximation is taken as (AA) %90 ratio, standard deviation standard deviation percentage (SD%) %98 and the coefficient of determination (R^2) 0,80. Results are analyzed by integrating geographic information system.

Key words

Analytic hierarchy process; forecasting; real estate; geographic information systems

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1 INTRODUCTION

The real estate valuation is defined as the sum of the necessary formalities for determining value of real estates objectively and disinterestedly by considering factors such as qualification, benefits, environmental conditions and usage. As real estate valuation is one of the important factors in country's economy, today its popularity is increasing. Real estate valuation treatments are used in a lot of areas such as taxing, hypothec treatments in banks, socialization, buying selling. In the areas that real estate valuation is needed, different approaches and estimation of the value are done. For this reason, each application's results show differences according to the studied real estate.

Land, as a factor of production and determiner of basic functions of life, has always remained in the agenda of economy, law and society since mankind's become sedentary until today. Both naturally possessed qualifications, wealth and its relative position artifactual values or the values given by it, constitute options. When the land is a matter of urban usage; it gains an economical value according to its functions within the construction borders and its function within real estate market. This value has different usage areas. Real estate valuation gains importance in matters such as being base for taxing, to be base for expropriation, selling real estates and sharing legacy.

Real estate valuation and reflecting it to taxing constitute one of the important economical sources of developed societies.Thus 56% of source of funds of the world is based upon real estates. Real estate valuation policy, which is not enhanced to a healthy structure, comes up in unjust profit sharings, privatization, unjust distribution in real estate taxing system and sometimes with economical source searches. Especially that real estate unit values which are determined by existing laws are extremely higher than their free market values increase the importance of the matter. As the discussions increase, it has become inevitable for countries' economies to make real estate valuation systems more healthy [1].

Determining real estate values objectively, truely and safely; is of great importance for social economy as well as real estate owners, sellers and buyers. Real estates constitute a large part of social fortune and everybody wants to know true value of their real estate [2]. In expropriations, land-area arrangements, taxings, municipality incomes, insurance, legacy, mortgages and inheritance processes, there is a constant need for the objective valuation of real estates. Valuation estimation methods have to be improved in order to be able to meet these requirements.

In literature there are collective valuation methods development studies which are called as automatic valuation methods. The most common of these methods are; artificial nerve network which is one of artificial intelligence methods, Artificial Neural Network (ANN) [3-6], fuzzy logic (FL)[7-9] and Support Vector Machine and Regression [4,10]. Analytic Hierarchy Process (AHP) which is one of the Multi-Criteria Decision Analysis (MCDA) methods is also among the developed studies in valuation [11-13].

In the study, estimation of real estates, according to AHP method, constructed in Selçuklu district in the Yazır avenue Konya/ Turkey is aimed. For this purpose, loads, which are acquired by using AHP method along with spatial and structural criterias, are transformed into values. Except for the performance analysis results between market values and AHP values, it is also done by GIS application.

2 METHOD

2.1 Analytic Hierarchy Process

AHP is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. It can also be among the methods which may be helpful in value estimation to make a decision in an organised way to generate priorities and for this we need to decompose the decision into the following steps [14].

1. Definition of the problem and determine the kind of needed knowledge. *(Problem in this study: Presence of more than one criteria, as being effective on the values of the real-estates, different structures of the criteria, and their bases on subjective reasons).*

2. Structuring the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives*). (location, physical and legal features).*

3. Construction of a set of pairwise comparison matrixes (1-2). Each element in an upper level is used to compare the elements in the level immediately below with respect to it. *Pairwise Comparison Matrix; (locational features 10X10 Pairwise Comparison Matrix, legal features 3X3 Pairwise Comparison Matrix, physical features locational of parcel 2X2, status of roads 5X5)*

$$A=\left[a_{ij}\right]=\begin{bmatrix} 1 & a_{12} & a_{13} & \dots & a_{1n} \\ 1/a_{12} & 1 & a_{23} & \dots & a_{2n} \\ 1/a_{13} & 1/a_{23} & 1 & \dots & a_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ 1/a_{1n} & 1/a_{2n} & 1/a_{3n} & \dots & 1 \end{bmatrix}_{n\times n} \quad (1)$$

$$a_{ij}^{*}=\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (2)$$

4. Using priorities obtained from the comparisons to weight the priorities in the level immediately below (3). Do this for every element. Then for each element in the level below its weighted is added to values and obtain its overall or global priority. Continue this process of weighting and adding until the final priorities of the alternatives in the bottom most level are obtained.

$$w_i=\frac{\sum_{j=1}^{n} a_{ij}^{*}}{n} \quad (3)$$

a_{ij}**:** Matrix elements of the pointed the reconstruction islands

n : Amount of the reconstruction island and criteria

$i, j = 1,2,3,\dots,n$

The processes above should be applied one-to-one and criteria which are considered as a given scale values according to their degree of importance (Table 1). This decision is made by an expert.

Tab. 1: The fundamental scale of absolute numbers

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	

2.2 Consistency Ratio of AHP

In the pairwise comparison method, criteria and alternatives are presented in pairs of one or more referees (e.g. Experts or decision makers). It is necessary to evaluate individual alternatives, deriving weights for the criteria, constructing the overall rating of the alternatives and identifying the best one. The matrix of pairwise comparisons A = [a_{ij}] represents the intensities of the expert's preference between individual pairs of alternatives [15]. Consistency Ratio (CR) is found in order to test the consistency of the comparison matrices. To do this, it is necessary to calculate λ by using the following equationas which are taken from [16].

$$D = \left[a_{ij}\right]_{n\times n} \times \left[w_i\right]_{n\times 1} = \left[d_i\right]_{n\times 1} \quad (4) \qquad E = \frac{d_i}{w_i} \quad (5) \qquad \lambda = \frac{\sum_{i=1}^{n} E_i}{n} \quad (6)$$

After λ is calculated, Consistency Index (CI) (7) and Consistency Ratio (CR) (8) are calculated.

$$CI = \frac{\lambda - n}{n-1} \quad (7) \qquad CR = \frac{CI}{RI} \quad (8)$$

Random Index (RI) is taken according to the number of decision options from Random Index by Saaty. If CR is calculated as $CR \le 0.10$, the assessment is consistent. However, if CR is calculated as CR>0.10, the assessment is not consistent, and must thus be refreshed.

3 APPLICATION

3.1 The study region

In the study, the area within Selçuklu district, which is dense in terms of size and population, on the ring road, within the bus terminal and university campus, is taken as application area. Valuation effecting criterias of the application area are grouped as belong to land and as belong to structure and addition is done. Data gathering is executed as two steps which are via map and by survey.

Data which is gathered via maps is; distance of the valuated real estate to healthcare organisation, education organisation, shopping mall, sanctuary, bus terminal and transportation netwok walking distance in meter.

And data gathered by survey is;

- **Number of floors:** The total number of floors allowed to be constructed on the practical construction plan,
- Age of the building: Difference between the year of certificate of occupancy of the building (where the flat is located) and valuation year,
- **Building area:** By multiplying the floor of the land given in the construction plan by the coefficient, the floor area of the building was found. This floor area is the area of an apartment that can be contained in an optimum area,
- **Heating type:** type of residential real estate heating system,
- **Front of the flat:** Front of the flat according to the building,
- **Security:** is there security for the houses situated in sites,
- **Parking:** the are which is left for habitants for a secure parking
- **Market value: Flat value (in TL) according to market conditions**

13 criterias which are gathered by surveying to 70 houses and map are organised to be used for valuation in AHP model. Map base is transferred into CBS and related with verbal characteristic information by graphic and 70 x 13 matrix.

Study steps are followed as seen in workflow diagram in Figure 1. Required AHP coefficients as a result of AHP application are transformed into value, and performance analysis are performed according to market condition values. AHP values are transformed into CBS and AHP comparisons are examined on thematic maps.

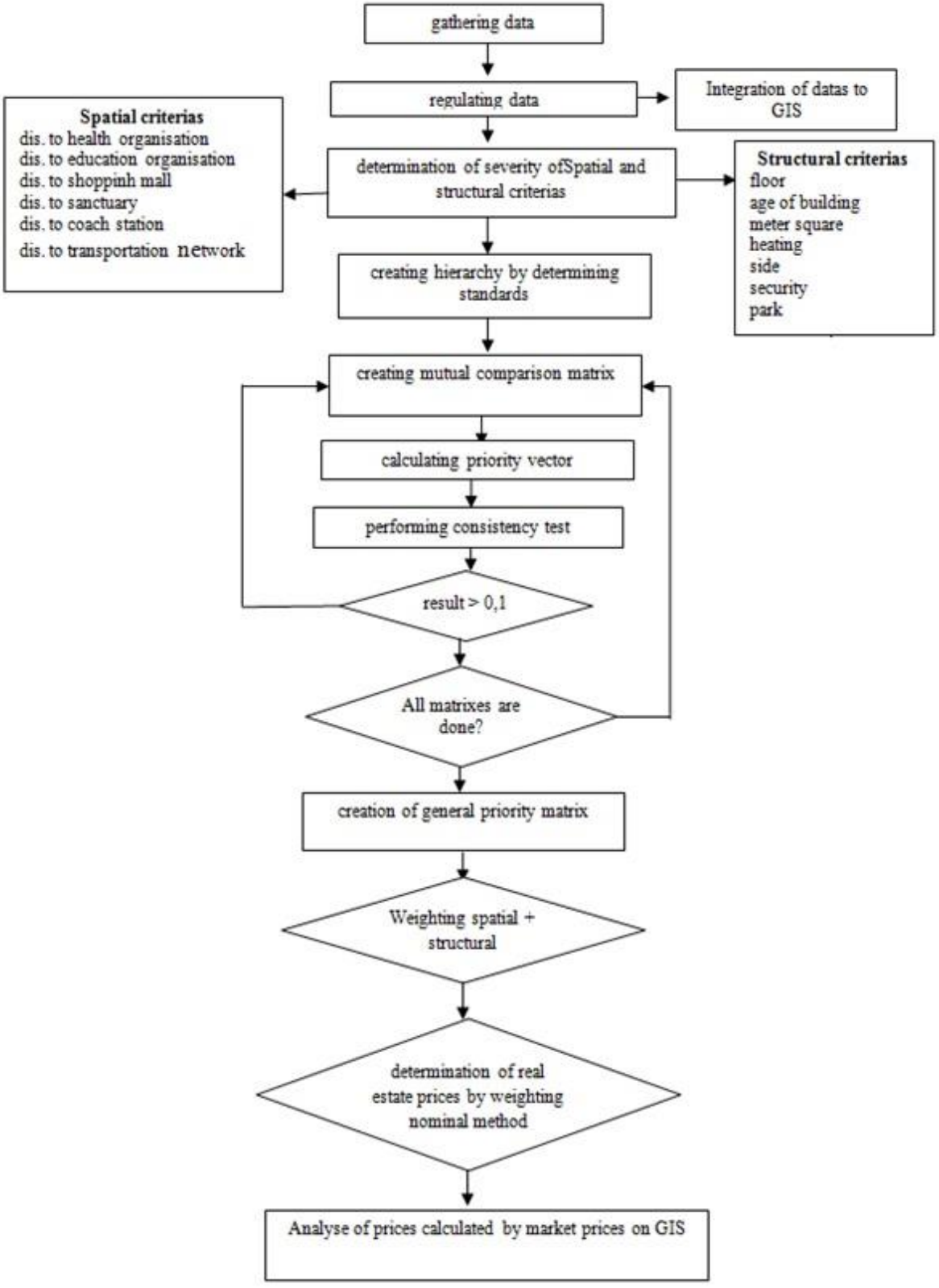

Fig.1: Workflow diagram of the study

3.2 Determination of Severities by AHP Method

AHP method is performed as 3 steps for houses

1. Measuring structural criterias
2. Measuring spatial criterias
3. Measuring two main criterias which are structural and spatial

Structural and spatial criterias are devided subgroups

A – Determination of Structural criterias' AHP weights: AHP is applied for 7 main criteria for the real estates which are subject to purchase and sell by surveyers. These criterias are divided into subcriterias and they are reduced into each criteria's weight. Weighting according to AHP method is applied in 3 steps as below.

Step1: Number of total floors, age of building, area, heating system, side, security and parking criterias related 7x7 mutual comparison matrix is created. "Normalised mutual comparison matrix" is acquired, in which collection of all values are equal to 1, by dividing each column's elements into sum of that column (Table 2).

Tab. 2: Calculating table of structural criterias

Criteria	Number of floors	Age of the building	Building area	Heating type	Front of the flat	Security	Parking
Number of floors	1.00	0.33	0.20	3.00	1.00	5.00	5.00
Age of the building	3.00	1.00	0.33	5.00	3.00	7.00	7.00
Building area	5.00	3.00	1.00	7.00	5.00	9.00	9.00
Heating type	0.33	0.20	0.14	1.00	0.33	3.00	3.00
Front of the flat	1.00	0.33	0.20	3.00	1.00	5.00	5.00
Security	0.20	0.14	0.11	0.33	0.20	1.00	1.00
Parking	0.20	0.14	0.11	0.33	0.20	1.00	1.00

Step 2: Column sum is aquired by adding each column values one under the other and elements of each column is devided in to the sum of that column. So, "normalised mutual comparison maxrix", in which sum of all values in which sum of all values are equal to 1, is required. (Table 3.). Aquired line approximations are weights related with key criterias. There is a consistency as CR values of each criteria is CR≤0.10 (Table 3).

Tab. 3: Rate of structural criterias' line points to sum of columns

CR=0,039 Criteria	Number of floors	Age of the building	Building area	Heating type	Front of the flat	Security	Parking	average of row
Number of floors	0.09	0.06	0.10	0.15	0.09	0.16	0.16	0.12
Age of the building	0.28	0.19	0.16	0.25	0.28	0.23	0.23	0.23
Building area	0.47	0.58	0.48	0.36	0.47	0.29	0.29	0.42
Heating type	0.03	0.04	0.07	0.05	0.03	0.10	0.10	0.06
Front of the flat	0.09	0.06	0.10	0.15	0.09	0.16	0.16	0.12
Security	0.02	0.03	0.05	0.02	0.02	0.03	0.03	0.03
Parking	0.02	0.03	0.05	0.02	0.02	0.03	0.03	0.03

Step 3: In this step, transformation to sub criterias from key criterias is done and weights of sub criterias are determined by performing applications in Step 1 and 2. After calculating weight coefficients of sub criterias, it is interpolated in a way that their own sum of weight give the weight of main criteria (Table 4.).

Tab. 4: Structural Criterias Table

Number of floors	**AHP kat puan= 0.12**	**Age of the building**	**AHP Building age point=0..23**	**Building area**	**AHP Alan Puan=0.42**	**Heating type**	**AHP heating point=0.06**
ground floor	0.01	0-5	0.13	50-100	0.02	Individual combi	0.0063
intermediate floor	0.08	6-10	0.06	101-150	0.06	Central combi	0.0154
top floor	0.03	11-15	0.03	151-200	0.11	central system	0.0374
		16-20	0.01	201 -	0.23		
TOTAL	***0.12***		***0.23***		***0.42***		***0.06***
Front of the flat	**AHP side point=0.12**	**Front of the flat**	**AHP side point=0.12**	**Security**	**AHP security point=0.03**	**Parking**	**AHP car park point=0.03**
northern	0.01	North east	0.01	available	0.03	available	0.03
southern	0.03	North West	0.00	absent	0.00	absent	0.00
East	0.01	South East	0.04				
West	0.00	South West	0.02				
TOPLAM			***0.12***		***0.03***		***0.03***

B – Determination of AHP Weights of Spatial Criterias: In this step of AHP method which is performed by datas required from map, 6 criterias in point of equipment are weighted by following processes stated in Step 1 and 2 (Table 5.).

Tab. 5: Weights of Spatial Criterias

Criteria	**Average**
Health	0.042227
School	0.042227
Shopping	0.093479
Place Of Worship	0.199182
Bus Station	0.199182
Transportation	0.423702

It is determined that building blocks in which 70 houses exist take place in 50 blocks. As the spatial criterias are effective for building block in the area more than the house itself,50x50 matrix is organised, which consist of blocks for the spatial distribution and AHP weights of 50 blocks, are determined for each spatial criteria. After calculating these weights, 50x6 matrix is created and multipied to the weights acquired in table 5 and spatial AHP weights of the blocks are acquired. (Table 6).

Tab. 6: Spatial Weights of Blocks

Blocks	Weight	Percent	**Blocks**		Weights	Percent		**Blocks**		Weights	Percent
20549	0.02563	2.56%	**24039**		0.02128	2.13%		**28411**		0.01339	1.34%
20548	0.02563	2.56%	**24043**		0.02079	2.08%		**28403**		0.01316	1.32%
20545	0.01786	1.79%	**29140**		0.01642	1.64%		**28398**		0.01520	1.52%
20544	0.01778	1.78%	**29141**		0.01642	1.64%		**16181**		0.02866	2.87%
20543	0.02530	2.53%	**15861**		0.01633	1.63%		**16178**		0.01789	1.79%
15863	0.02530	2.53%	**15860**		0.02216	2.22%		**15642**		0.01789	1.79%
15864	0.02114	2.11%	**15859**		0.01730	1.73%		**17125**		0.01595	1.60%
20542	0.02067	2.07%	**20160**		0.02189	2.19%		**20823**		0.01498	1.50%
20541	0.01801	1.80%	**20526**		0.03299	3.30%		**16190**		0.01595	1.60%
20540	0.01592	1.59%	**18981**		0.02772	2.77%		**17127**		0.02642	2.64%
20537	0.01639	1.64%	**18982**		0.03883	3.88%		**16187**		0.02564	2.56%
20538	0.01923	1.92%	**15594**		0.02189	2.19%		**22530**		0.01777	1.78%
20539	0.01905	1.91%	**28391**		0.01227	1.23%		**21200**		0.02416	2.42%
29201	0.01618	1.62%	**28390**		0.00981	0.98%		**21796**		0.02703	2.70%
21390	0,03162	3.16%	**28404**		0.01127	1.13%		**21791**		0.02241	2.24%
16181	0,02866	2.87%	**29116**		0,01328	1.33%		**20560**		0,01328	1.33%
20569	0,03303	3.30%	**20552**		0,02060	2.06%					

C – Weighting of Structural and Spatial Key Criterias: It is necessary to acquire one common coefficient from these two key criterias in order to be able to make price analysis. Thus weighting of spatial and structural criterias are performed. (Table 7).

Tab. 7: Spatial and Structural criteria scoring table

CR=0	Average
Spatial	0.70
Structural	0.30

After determining spatial and structural key kriterias' weights, these weights are multipied with weights of structural (Table 4) and spatial (Table 6) criterias, which we have determined previously, and AHP points of 70 houses are acquired.

As house related AHP results are needed to be transformed into values, average of AHP results ($AHP_{ort.}$ = 0.10298) and sale values (Market $value_{ort}$ = 158.943) are based on and AHP results are transformed into AHP values.

3.3 Integration of Datas with CBS:

Construction plan bases of the study are edited and opened in NETCAD in ArCgis software and organised by creating block and building layer. Data set is related with this map in arcgis so, verbal information (data set) is added to graphical information (map) (Figure 2).

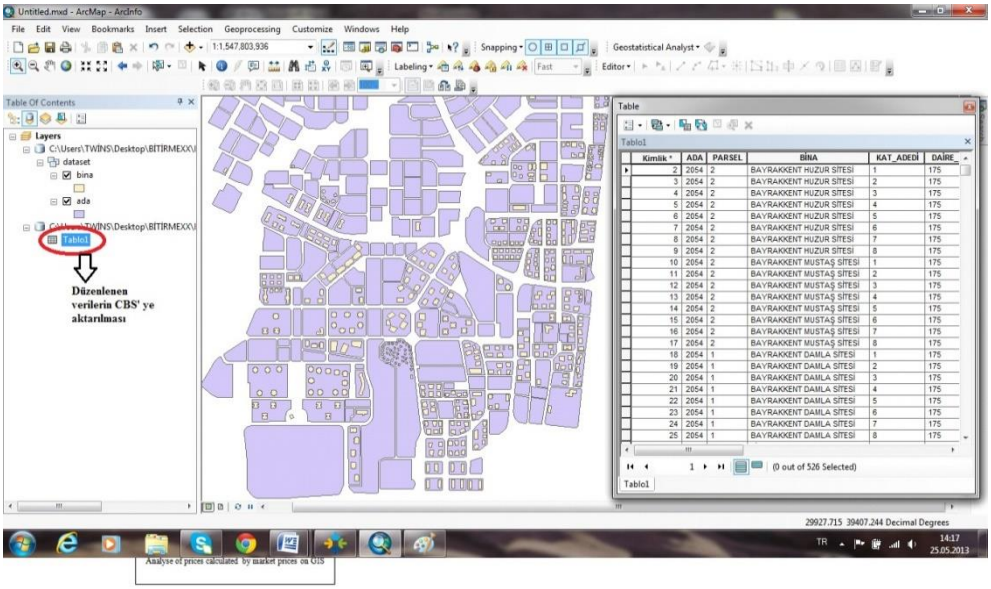

Figure. 2: View of study area's information on Arcgis

As the acquired performance analysis of the values show enough consistency, AHP values are also tranferred into arcgis program. Analysis results of both AHP values and map related Figure 3 are seen.

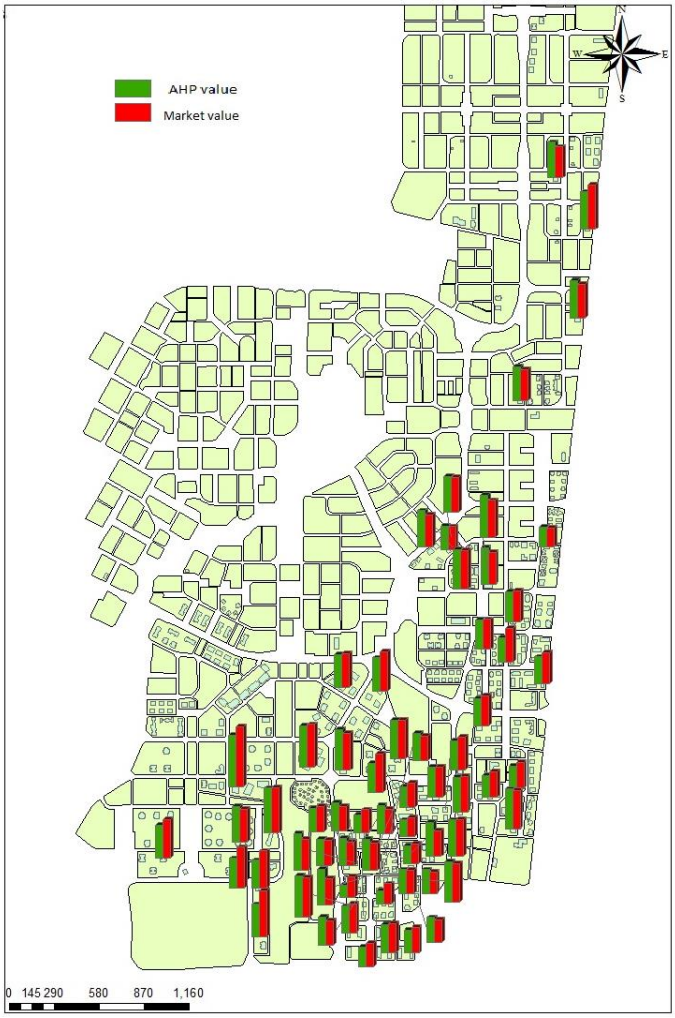

Fig. 3: Comparison of Market Value and Calculated Values

4 RESULTS AND DISCUSSION

It is seen in the distribution between market values and AHP values that AHP values are successful in estimating the market values in the system formed by using the Multi-Criteria Decision Analysis approach in real estate valuation through criteria classification (Figure 4).

Since the target in the practice is to estimate the market price, a performance valuation is presented with a curve in Figure 5 to show the extent to which AHP values estimate market prices. In y=ax equation, the closer a and R^2 are to 1, the more accurate the model is. Based on Figure5, now that R^2= 0,80 and y=0,98*x are obtained, it is observed that AHP model yields a good result in estimating the value of plots.

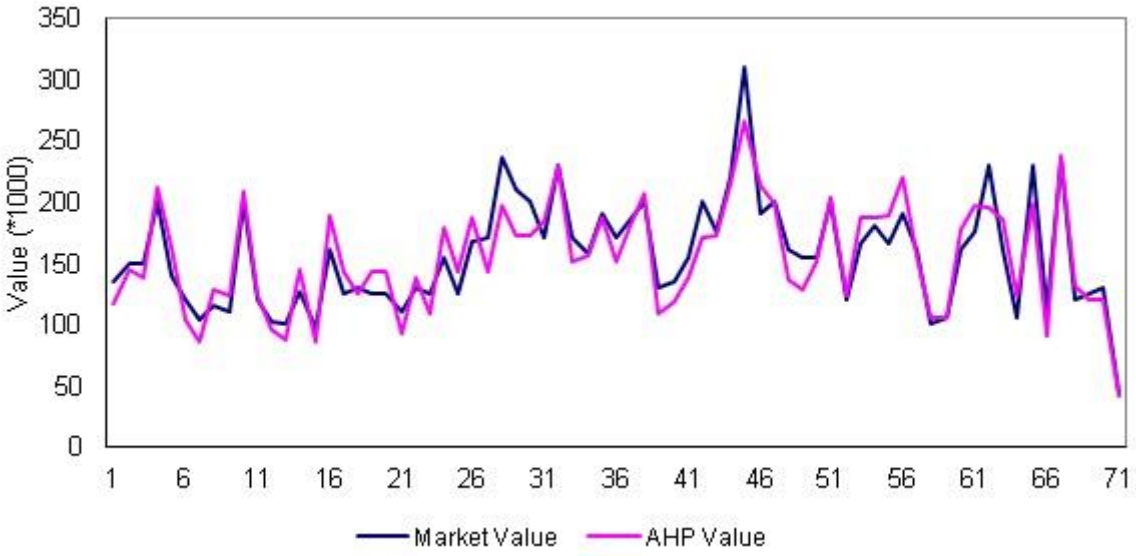

Fig. 4: Market values and the estimate of AHP

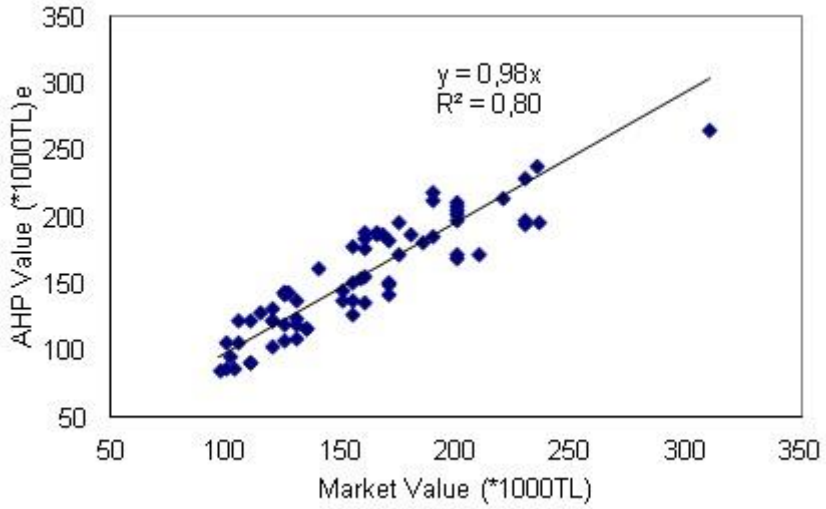

Fig. 5: Regression line between the market values and AHP values

The average approximation% (AA%) was obtained from Equation 9. and Equation 10. for the Standard deviation.

$$AA\% = \frac{\sum_{i=1}^{n} 1 - \left(\frac{\left| x_p - x_i \right|}{x_p} \right)}{n} * 100 \quad (9) \qquad SD = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x_i})^2}{(n-1)}} \quad (10)$$

x_p :Market value, x_i :Value of the model, i : {1,2,3….n}, n :Total number of the residential real-estates in the data set

AA% of AHP model are calculated 90% and standard deviation percentage (SD%) %98 in general terms. It is understood from the comparisons that estimations of AHP model are successful.

5 CONCLUSION

The applicability of AHP method in real estate value estimation is investigated in this study. The criterias that effect the value of the real estate are divided into 2 stages (spatial attributes and structural attributes) in this study. The purpose of the study is to integrate GIS system of AHP method and to production house value map. Choice of AHP method due to ease of understanding and operation, it may be utilized as the basis for drawing up of thematic value maps via GIS, and for all the processes (taxing, expropriation, banking transactions, etc.) which require real-estate valuation.

The most important difference of AHP is that it is appraised from criterion groups (spatial and physical) within their own and assign the points to each criterion. Because structures, units, importances and values of subcriteria within criterion groups are different, the using criteria of weight points calculated by AHP are brought homogeneity in respect to units and values. GIS is a system which develops in parallel with the computer technology, and becomes a part of our daily lives. GIS is necessary for the instant display of all details of the real-estates at a time, and for conducting the analyses thereof. Results of the AHP method, which are applicable for real-estate valuation, are integrated in GIS software, and thematic map has visually been drawn up.

AHP method becomes a supportive method in the issue of setting a model for real-estate valuation. It may thereby be utilized in all valuation processes. Besides expropriation, insurance, privatization, and taxation in particular, also valuation processes integrated with GIS will be proceed more easily, more quickly, and more accurately.

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