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POSITIONAL DETERMINATION OF REAL ESTATES WITH ANALYTIC HIERARCHY PROCESS

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Abstract- Real estate valuation is used in a wide range of areas, such as buying and selling among individuals, processes of taxation in municipalities and crediting in banks. A lot more processes such as privatization, socialization, plot and land application are also needed for valuation. Different values for each of these processes are encountered in real estate valuation. Every corporation/organization carries out their own valuation. It is difficult to find the real value of the real estate. For of both objective and subjective reasons, different approaches are exhibited as regards valuation.

In this study, Analytic Hierarchy Process (AHP), which is one of the Multi-Criteria Decision Analysis (MCDA) methods, is applied for solving the real estate valuation problem's position-related part. Positionally important criteria, which affect the value of a real estate, such as the distance of real estates to transportation network, healthcare organization, schools, sanctuaries, green areas, shopping centers and busy parts of the city are considered and analyzed after choosing Konya/Selçuklu as the application region. Consequently, a coefficient is obtained according to the positional properties of the reconstruction islands in the determined region. These coefficients will be able to be used in such processes as valuation of a real estate, crediting and taxation.

Key Words: Real estate valuation, Multi-Criteria Decision Analysis, Analytic Hierarchy Process, spatial criteria

1. INTRODUCTION

Real estate valuation is the process of assessing a real estate accurately and objectively by considering its properties according to the economical conditions in a specific time. Knowing the value of a real estate will facilitate a lot of process about the real estate. For instance, taxation of real estates, crediting, socialization, zoning regulations, insuring, customizing and even more processes will be easier. In this context, the values of all real estates should be determined. But the existence of subjective reasons besides objective reasons makes this process a little difficult. Additionally; " real estate valuation processes appear as a chaotic situation which does not have a specific legal basis, far from being scientific and objective and sustained via subjective decisions and judgments, whose control mechanism is conducted through personal perceptions, whose consistency is not inspected and in which equality is not questioned [1]."

There are a lot of criteria which affect the value in real estate valuation. While some of these criteria may find a numerical counterpart, others can not. It is especially difficult to get a counterpart for the value increase or decrease of the real estate sourced by the position of the real estate. What is meant by position is the distance of the real estate to or from specific areas. These areas are shopping centers, green areas, healthcare organizations etc. These are factors that lead to an increase in the value, but there are also factors that cause a decrease in the value such as railways and waste yards. It is difficult to determine a value by handling each of these factors. “When people are faced with a complex problem in order to understand the problem better, they must break down the problem into its smaller constituent parts and construct a hierarchical model to represent it [2].”

Multi-Criteria Decision Analysis (MCDA) is a decision making process by which more than one criterion are considered about an event or a fact.” It is based on modeling the decision process according to the criteria and analyzing them [3].” MCDA has many forms of application such as WSM-The Weighted Sum Method, WPM-The Weighted Product Method, ELECTRE-Elimination Et Choix Traduisant la Realité Metod, TOPSIS-Technique for Order Preference by Similarity to Ideal Solution Method and AHP-Analytic Hierarchy Process. One of the most widely used is AHP.

Analytical Hierarchy Process (AHP) makes the decision making process easier “by choosing the best alternative which meets all criteria of the decision maker [URL 2]”. It also succeeds by making comparisons among the criteria. “To make comparisons, we need a scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion or property with respect to which they are compared [4].”

Analytical Hierarchy Process (AHP) is used for decision making in complex events in a lot of areas such as industry, computer, mapping an area, enterprises and economics. For instance, multi-criteria decision making processes are applied in career planning [5], choosing the best car [3], ordering university preferences [6], choosing locale for hospital [7], choosing computer for a business [8] and assessing construction project investments [9]. Mapping an area is used in comparison of multi-criteria evaluation methods integrated in Geographical Information Systems (GIS) to allocate urban areas [10], the GIS-based land-use suitability procedures [11], spatial decision problems [12], the work of real estate valuation and the ratio with Multi-Criteria Decision Systems (MCDS) [1].

It is believed that, in real estate valuation, AHP method will be a solution to explicating spatial criteria. Applicability of the method should be examined so as to express spatial criteria which are one of the most important real estate value-affecting factors, find a numerical counterpart which is ready to be applied in other models and reduce the criteria that affect the value.

In this study, what sort of differences emerge among ten reconstruction islands when their locations are considered is investigated by considering spatial distribution (their distances to specific places) of the region which is chosen from Konya/Selçuklu region. By AHP technique, their distances to transportation network, healthcare organization, schools, sanctuary, green areas, shopping centers and busy parts of the city are determined as *criteria*. The reconstruction islands are compared according to these criteria and the other steps of the process are applied. In this way, it is shown that it is possible to obtain a single coefficient through AHP which will represent spatial criteria that are among the most important factors which affect real estate value in valuation.

2. MATERIAL AND METHOD

There are a lot of criteria which affect real estate value. These criteria vary according to the structure of the region which will be valued and the socio-cultural situation of the people living there. In addition, there are many factors like meteorological conditions.

It is necessary to use different criteria for the real estate which will be valued. Therefore, real estates should be classified according to thier priority of usage as houses, lands, business offices or agricultural areas. Common criteria among these real estates are spatial ones. Spatial criteria are;

Value-increasing spatial factors
Distance to social places
Distance to transportation network
Distance to business centers
Distance to shopping centers
Distance to sanctuary
Distance to healthcare organizations
Distance to recreation areas

2.Value-decreasing spatial factors
Distance to industrial areas
Distance to railways
Distance to wasteyards

The criteria may as well be divided into other sub-sections.

2.1. Multi-Criteria Decision Analysis

Decision making is to obtain a result by comparing more than one option according to one or more criteria. The decision maker can think that some criteria are more or less important for a problem than the others. For this reason, the most important step of the decision making process is to determine the weights of criteria, based on the relative importance [12].

The main methods used as the most common in MCDA [9] are as follows;
WSM-The Weighted Sum Method,
WPM-The Weighted Product Method,
ELECTRE-Elimination Et Choix Traduisant la Realité Method,
TOPSIS-Technique for Order Preference by Similarity to Ideal Solution Method,
AHP-Analytic Hierarchy Process.

Analytic Hierarchy Process (AHP) is the most coomonly used method. AHP is a method which will allow decision making in solving complex problems.

2.1.1. Analytic Hierarchy Process

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then [URL 1].

AHP is the "multi-criteria decision-making method based on ordering the alternatives by assessing one-to-one. Aims and sub-aims are defined within a hierarchy and as nested layers [3]." AHP method is a good method to solve a complex problem.
AHP method is also widely used in the mapping. Especially it is seen that AHP method is being used in spatial analysis, in GIS [1, 10-12], in choosing the place of an important building [13], [7]. Moreover, there are also samples which are applied by integrating fuzzy logic with AHP method [5-7].
To make a decision in an organised way to generate priorities, we need to decompose the decision into the following steps [4].
1. Define the problem and determine the kind of needed knowledge.
2. Structure 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).
3. Construct a set of pairwise comparison matrices(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;

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

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

4. Use the 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 add its weighted 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
$i, j = 1,2,3,.....,n$ [13].

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

Table 1. The fundamental scale of absolute numbers [4].

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

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 formulas which are taken from [14].

$$D = \lfloor a_{ij} \rfloor_{n\times n} \times [w_i]_{n\times 1} = [d_i]_{n\times 1} \quad (4)$$

$$E = \frac{d_i}{w_i} \quad (5)$$

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \quad (6)$$

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

$$CI = \frac{\lambda - n}{n-1} \quad (7)$$

$$CR = \frac{CI}{RI} \quad (8)$$

Random Index (RI) is taken according to the number of decision options from Random Index Table by Saaty. If CR is calculated as $CR \leq 0.10$, 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

The study region is in the city of Konya, on the Konya-Afyon ring road, behind the bus terminal, ten km to the Aleaddin Keykubat Campus of the Selçuk University. In this region, ten reconstruction islands which are randomly chosen are numbered, starting from 101. Spatial features of the reconstruction islands in the study region are taken into consideration with respect to their bird's-eye view distance from the social facilities. There are social facilities in the region; a secondary school, a market place, a sanctuary, a primary health care center and a park place. There is also a ring road close to the region. In the busy part of the region, there are Selçuklu Municipality Building, a very big shopping and entertainment center, boutiques, commercial centers and business centers.

Seven criteria present in the region are as follows; distance to healthcare organization, distance to transportation network, distance to school, distance to sanctuary, distance to green areas, distance to shopping center, distance to busy parts of the region.

A problem needs to be determined in order for the method of AHP to be applied. The problem to be solved is the determination of the differences in terms of the position of the real estates. If these real estates have different coefficients because of their position, their values should also be different. To achive this aim, the AHP method should be carefully applied step by step.

AHP method is modeled in a hierarchical way. "Hierarchy generally consists of at least three levels. According to this, on top of the hierarchy is the general aim of problem, and criteria and options are located below it, respectively [12]." (Figure 1).

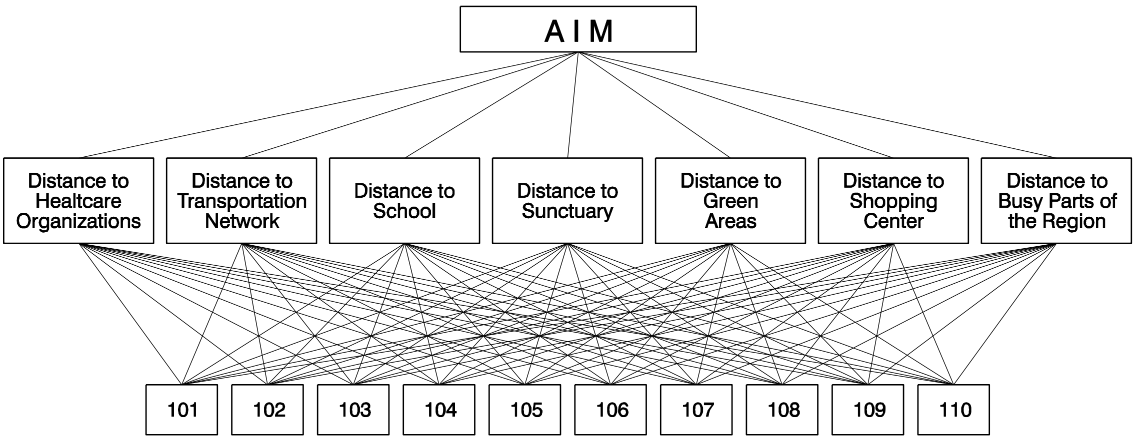

Figure 1. Hierarchical Structure of Analytic Hierarchy Process

Alternatives are the reconstruction island such as 101, 102, 103,…, 110. Criteria are healthcare organization, transportation network, school, sanctuary, green areas, shopping center, busy parts of the region. Pairwise comparison matrices were created for each criterion.

I. Process: Matrices are created as many as the number of criteria (there are seven criteria for the application in here consisting of 10x10 matrices). Their lines and columns consist of the numbers of the reconstruction islands. The diagonals of matrices are one and the values above the diagonal are given points by considering scale values according to status of the reconstruction island compared with each other for the relevant criterion. The downside of the diagonal is found by taking the opposite values of upside values of the diagonal. Only the points of the reconstruction islands according to their distance to Healthcare Organization are shown in Table 2.

The number of decision options is ten. Provision of ten is "1.49" in Random Index Table by Saaty.

Table 2. Pointing of the reconstruction islands according to their distance to Healthcare organization.

CR=0.0607	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**
101	1	3	3	3	5	3	3	1/5	1/7	1/7
102	1/3	1	1	1	3	1	1	1/7	1/9	1/9
103	1/3	1	1	1	3	1	1	1/7	1/9	1/9
104	1/3	1	1	1	3	1	1	1/7	1/9	1/9
105	1/5	1/3	1/3	1/3	1	1/3	1/3	1/5	1/7	1/7
106	1/3	1	1	1	3	1	1	1/5	1/7	1/7
107	1/3	1	1	1	3	1	1	1/5	1/7	1/7
108	5	7	7	7	5	5	5	1	1/5	1/3
109	7	9	9	9	7	7	7	5	1	1/3
110	7	9	9	9	7	7	7	3	3	1
Total of Columns	21.867	33.333	33.333	33.333	40.000	27.333	27.333	10.229	5.105	2.571

II. Process: (10X10) Another matrix is obtained by applying the first formula (2) to all matrices found for each criterion in 1st process. Weights are calculated by taking into account the mean of each line according to the second formula (3). Weighted matrices form as a result of 10x1 line averages from each of the criteria. The assembled form of these matrices is seen in Table 3. Also each line in Table 3 should be equal to 1.

Table 3. Weight matrix of the reconstruction islands according to each criterion

Recons-truction Islands	**Health**	**Trans-portation**	**School**	**Sanctuary**	**Green Areas**	**Shopping**	**Busy**
101	0.076	0.017	0.099	0.253	0.190	0.022	0.063
102	0.033	0.017	0.099	0.242	0.190	0.022	0.032
103	0.033	0.032	0.266	0.128	0.190	0.081	0.027
104	0.033	0.062	0.160	0.060	0.098	0.199	0.019
105	0.019	0.118	0.071	0.029	0.056	0.211	0.019
106	0.036	0.205	0.037	0.029	0.030	0.211	0.048
107	0.036	0.337	0.035	0.018	0.020	0.091	0.089
108	0.162	0.118	0.016	0.056	0.015	0.021	0.344
109	0.263	0.062	0.042	0.056	0.034	0.051	0.184
110	0.309	0.032	0.174	0.128	0.176	0.090	0.175
TOTAL	**1**	**1**	**1**	**1**	**1**	**1**	**1**
CR	**0.0607**	**0.0531**	**0.0448**	**0.0299**	**0.0468**	**0.0322**	**0.0838**

III. Process: The criteria above are assessed according to comparisons within themselves. This comparison is done by thinking in the way that "which criterion is more important and has more priority than the others" for people (Table 4).
The number of decision options is seven. Provision of ten is "1.32" in Random Index Table by Saaty.
IV. Process: By applying the formulas no.2 and 3 to the matrix in Table 4, the matrix of the weights of criteria given in Table 5 is found.
V. Process: In the latest step of the process, the result of the multiplication of these Table 3 and Table 5 matrices is given in Table 6. Table 6 shows spatial percentage slices of the reconstruction islands according to the criteria dealt. In this way, spatial differences of the reconstruction islands are determined and seven criteria are reduced to one value.

Table 4. Scale values of criteria

CR=0.0368	Health	Trans-portation	School	Sanctuary	Green Areas	Shopping	Busy
Health	1	1/9	1	1	1/5	1/3	1/7
Transportation	9	1	9	9	5	7	3
School	1	1/9	1	1	1/5	1/3	1/7
Sanctuary	1	1/9	1	1	1/5	1/3	1/7
Green Areas	5	1/5	5	5	1	3	1/3
Shopping	3	1/7	3	3	1/3	1	1/5
Busy	7	1/3	7	7	3	5	1

Table 5. Weight matrix of criteria

CRITERIA	WEIGHT
Health	0.034
Transportation	0.431
School	0.034
Sanctuary	0.034
Green Areas	0.143
Shopping	0.077
Busy	0.249

Table 6. Percentages of the reconstruction islands according to their positions

Reconstruction Islands	WEIGHT	PERCENTS
101	0.066	%6.6
102	0.057	%5.7
103	0.068	%6.8
104	0.069	%6.9
105	0.084	%8.4
106	0.124	%12.4
107	0.180	%18.0
108	0.148	%14.8
109	0.094	%9.4
110	0.110	%11.0

3. RESULTS AND DISCUSSION

AHP, which is one of the Multi-Criteria Decision Making techniques, is applied to the reconstruction islands chosen in this application by considering their distances to healthcare organization, transportation network, school, sanctuary, parks, markets and city center. The positions of the reconstruction islands are assessed according to seven criteria. These seven criteria has been transformed into one value by Analytical Hierarchy Process method. Coefficient values also represent weights of the reconstruction islands according to their spatial properties. As seen in Figure 2, the island numbered 107 has the highest value in comparison with the others according to the results obtained. The accuracy of this result is understood because the island numbered 107 is the closest to transportation network. At the same time the island numbered 107 is also seen close to market place, school and park place. The reconstruction island numbered 102, which has the lowest coefficient, is the farthest island to the transportation network. Although the island numbered 102 is close to park place, school and market place, it is far from primary health care center and sanctuary.
AHP method is applied to spatial criteria, and comparison is done among the criteria. Weight coefficients of the criteria are found as seen in Table 5. It is seen that the coefficient for transportation network is higher than for the other ones. Because roads will take the people to the places (work, house, school, hospital,…etc) where they want to go, transportation network is also observed through AHP to be important.

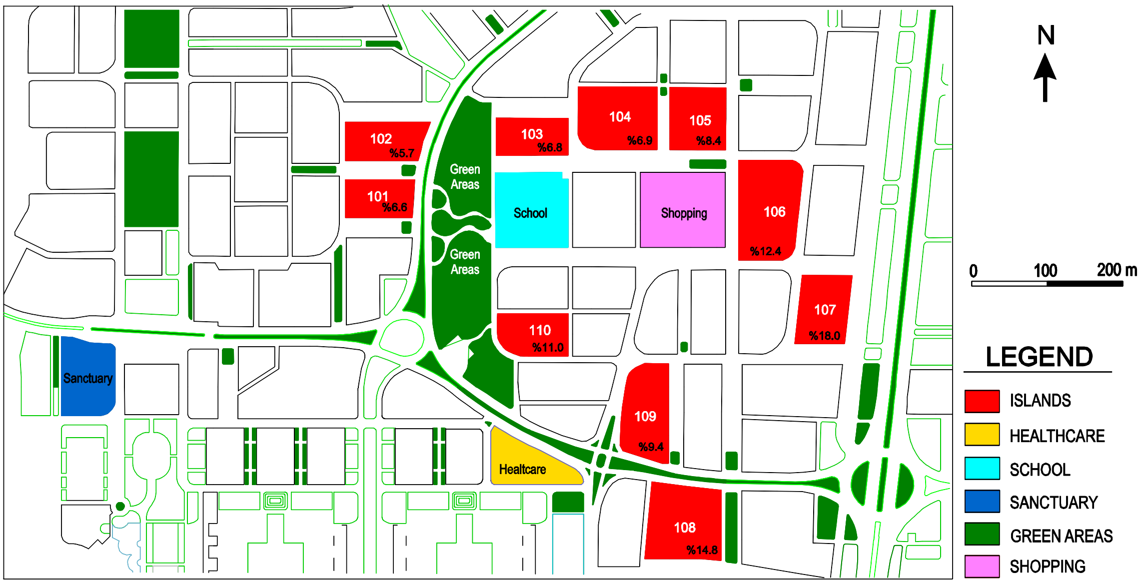

Figure 2. Showing results in chosen region

4. CONCLUSIONS

Real estate valuation is a system which hosts a combination of many objective and subjective elements. So it is difficult to model it. Position-based criteria which host the most important criteria that affect the value are approximated subjectively. But this study shows that a single coefficient for representing objective and spatial criteria can be expressed by AHP.

In this study, a system is designed which can be used for real estate valuation through AHP method and which produces a coefficient for each island by determining spatial weights of the reconstruction islands. In this system, a coefficient is derived for the reconstruction islands. These coefficients can also be a base for crediting, taxation, valuation of the real estate and a lot more processes. For instance, municipalities can use AHP method in taxation processes. AHP is a better method when it is compared with the already existing method which conducts taxation by municipalities according to the streets. A similar application of AHP method can be done, in which way the island weight coefficients can be derived for all the reconstruction islands by dividing the city into regions. Decision-making in connection with real estates will be easier in this type of application.

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