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Importance analysis of the criteria affecting the house selection with the analytical hierarchy process

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Abstract

Houses meet the housing needs of people. At the same time, it draws attention as a means of status, social acceptance and investment. Therefore, housing is important for individuals and families. The house selection should be deal with as a multi-criteria decision problem for containing many criteria and effecting factors. In order to obtain an objective result in determining the importance of criteria in house selection, multiple decision maker analysis is needed. For these purposes, a total of 20 sub-criteria in 3 basic groups were examined for criterion selection in this study. Then, the importance levels of these criteria were determined using the Analytical Hierarchy Process. While determining the degree of importance, answers were taken from 15 decision makers (the student of Geomatics Engineering) and pairwise comparison matrices were created. The weights of the criteria were obtained with the Analytical Hierarchy Process and the importance levels of the criteria were determined as a result of the study. Also, the importance of criteria analyzed.

1. Introduction

The real estate is independent and permanent rights that give the owner the right to use it as they wish, registered on different pages in the independent sections registered in the title deed and condominium, excluding the prohibitions developed in favor of the citizens [1]. Housing is the living space where people continue their lives and generations by meeting to need for shelter. Houses have undergone many changes in social, cultural, economic, technological and legal terms over time [2]. A large number of financial resources are needed for buying or renting a house. The wishes, economic reasons, social factors etc. are also effective in the house selection. House selection has turned into a multi criteria decision making problem with the increase in housing options and evaluation criteria. For these reasons, it is necessary to make the right choice by expressing the criteria according to which the house is evaluated as much as possible numerically. Multi criteria decision making methods can be used to find the best solution by evaluating many criteria that are effective in the house selection [3].

Each house has its own unique feature in terms of its location. Therefore, a house cannot be exactly the same, but when expressed as a value, another one with the same value can be found like real estate. Another issue to consider is the subjective values that buyers use when house selection [4]. The buyers have their own preferences. Some may want a good physical environment, an area close to parks and green spaces, while the other may want an area close to the school. These preferences of the buyers are effective in the house selection [5-6].

When the studies on house and real state selection in the literature are examined, it is seen that, a few methods have been used. Analytical Hierarchy Process (AHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) methods from multi criteria decision making methods, regression analysis and hedonic methods as statistical methods, fuzzy logic and artificial neural network methods as modern methods are used frequently. [1,2, 7-10].

In this study, the importance levels of the criteria taken into account in the house selection were analyzed using the AHP method for the answers received from undergraduate students of geomatics engineering. The pairwise comparison matrices in AHP method were created for the criteria affecting the house selection and their weights were determined.

2. Material and Method

It is important to examine house criteria mathematically for finding the right choice. In the house selection, it must be to evaluate many criteria together. For this reason, in the solution requires a multi-criteria decision-making process. Multi-criteria decision making process evaluates many criteria together and assigns values to options. The AHP method, which is one of the multi-criteria decision-making methods, was used to determine the importance levels of the criteria considered in the house selection in this study. The answers of the creation of pairwise comparison matrices were collected from undergraduate students of geomatics engineering were taken as data. The reason of selection these students is that real estate appraisal is a geomatics engineering study area, taken real estate appraisal course and not have work experiences.

2.1. Analytic Hierarchy Process (AHP) Method

The analytical hierarchy process was first introduced by Myers and Alpert in 1968 and developed by Saaty in 1977. AHP is a method that can be used in solving multi criteria decision making problems [3].

The problem with the AHP method developed for complex decision problems involving more than one criterion; It is modeled in a hierarchical system at the level of main purpose, criteria, sub-criteria and options. The hierarchy consists of at least three levels. Accordingly, at the top of the hierarchy (Figure 1), there is the general purpose of the problem, and below the goal, there are criteria and alternative, respectively [11-15].

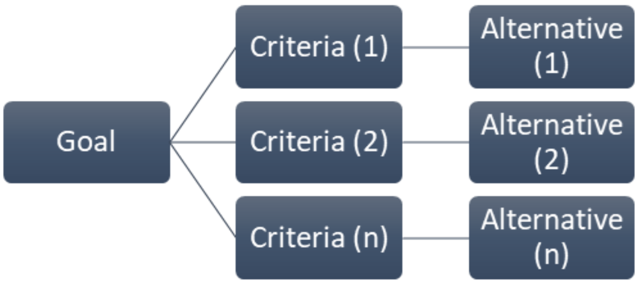

Figure 1. AHP Workflow

The application steps of the AHP method are as follows under 5 headings [2,3,11,13,16-23]:

1) Determination of decision criteria: Criteria and alternatives of the problem are determined.

2) Creation of the pairwise comparison matrix: After determining a decision criteria of problem, the pairwise comparison matrix of the criteria $A_{n,n}$ is created. Here, n is the criteria number. The criteria are compared among themselves using the pairwise comparison scale given in Table 1.

3) Obtain the single judgement: This step is applied if there is more than one decision maker. If the analysis is to be done with a single decision maker, this step should be skipped. One of the important issues of decision analysis is to obtain a single judgement by combining the evaluations of the decision makers in the group. In the analytic hierarchy process, the geometric mean of the matrices is taken to consolidate the judgements of the decision makers. The final value is obtained by taking the power of the decision makers' evaluations according to their importance.

4) Calculation of weights: A pairwise comparison matrix is created (Equation 1) and each value is divided by the column total to which it belongs (Equation 2). The sum of the values in each column of the resulting normalized matrix should be "1,00". The weight vector W is obtained by averaging the values in each row of the normalized matrix (Equation 3).

5) Checking the consistency: The consistency ratio (CR) is calculated for each pairwise comparison matrix. The upper limit for the consistency rate recommended by Saaty is "0,10". If the calculated consistency ratio is greater than "0,10" the pairwise comparison is must be re-evaluated. The basis of the consistency ratio is based on the comparison of the number of criteria with a coefficient called the baseline value (λ) (Equation 4-5). After calculating the basic value (λ) coefficient, the CR is calculated (Equation 6). Random consistency index (RI) are given in Table 2. Comparisons are said to be consistent if "CR≤0,10". The CR is close to zero, the more consistent

the comparison results will be. In case of "CR>0,10" the results obtained are inconsistent and should be reconsidered.

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & 1 & a_{23} & \dots & a_{2n} \\ a_{31} & a_{32} & 1 & \dots & a_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & a_{n3} & \dots & 1 \end{bmatrix} \quad (1)$$

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

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

$$[d_i] = [a_{ij}]\ x\ [w_i] \quad (4)$$

$$\lambda = \frac{\sum_{i=1}^{n} d_i / w_i}{n} \quad (5)$$

$$CR = \frac{\lambda - \mathrm{n}}{RI(n-1)} \quad (6)$$

Table 1. Comparison Scale in AHP

Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong Importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, it dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation

NOTE: 2, 4, 6, 8 can be used to express intermediate values

Table 2. Random Consistency Index Values

(n)	1	2	3	4	5	6	7	8	9	10	11	12
(RI)	-	-	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48

2.2. Material

In the house selection, the buyer wishes should be taken into account. For this reason, previous studies were examined and information was collected about the criteria used in the house selection. In the Alkan and Durukan [3] using AHP and TOPSIS methods, the criteria of price, usage area, age, floor, number of rooms, number of sun facades/landscape, heating system and distance to the city center were examined. In the Tabar [24] using artificial neural networks and fuzzy logic method, the criteria of apartment area, number of rooms, building age, floor of the apartment, heating type, number of bathrooms and balcony were examined. In the Bozdağ and Ertunç [25] using the AHP method, it was stated that the main criteria and sub-criteria should be determined. E.g; The distance to work and work area, which belongs to the location and is specified as a sub-criterion, can be in different ways by people.

As a result, when the studies in the literature are examined, it is seen that various criteria are preferred in the house selection [16,26-30]. Frequently preferred criteria for selection are given in Table 3.

At the end of the literature review, it was decided to determine the basic criteria and the sub-criteria related to these criteria. General features of the building were selected as basic criteria and it was divided into 3 groups as detailed features, spatial features and environmental features. Then, 20 criteria affecting the house selection were selected as sub-criteria. These criteria are: number of rooms, building area, balcony, en-suite bathroom, floor location, building age, heating system, elevator, proximity to city center, proximity to educational institution, proximity to health center, proximity to main road, proximity to worship areas, proximity to parks and gardens, proximity to the workplace, building parking, public transport stop, bening on the site, neighborhood, facade/landscape.

Table 3. Frequently Used Criteria in the Literature [2]

Criteria Name	Criteria Name
Building Price	Proximity to city center
Proximity to Public Transport	Number of Sunny Facades
Neighborhood	Building Area
Car park	Number of Rooms
Playground	Sound and Heat Insulation
Green Area	Dues and Expenses
Proximity to School	Bank Loan Eligibility
Proximity to Hospital	Building Age
Proximity to Social Areas	Floor location
New/Pre-owned Condition	Total Floor in the Building
Heating system	Security

The criteria are grouped as given in Table 4. The grouped criteria were analyzed by preparing pairwise comparison matrix.

Table 4. Criteria Used in the Study

Building General Features	Sub-Criteria
1) Building Detail Features	1) Number of Rooms 2) Building Area 3) Balcony Condition 4) En-suite Bathroom 5) Floor location 6) Building Age 7) Heating system 8) Elevator
2) Building Spatial Features	1) Proximity to City Center 2) Proximity to Educational Institution 3) Proximity to Health Center 4) Proximity to Main Road 5) Proximity to Worship Areas 6) Proximity to Parks and Gardens 7) Proximity to the Workplace
3) Building Environmental Features	1) Building Parking 2) Public Transport Stop 3) Being on the Site 4) Neighborhood 5) Building Facade / Landscape

3. Results

The paired comparison matrix was created for the 3 main criteria and sub-criteria related to them in the house selection. In the study, the answers of 15 undergraduate students were used. The steps of the AHP method were applied to the data obtained as a result of the evaluation of the decision makers.

The paired comparison matrix and consolidated matrix for Building Detail Features, Building Spatial Features, Building Environmental Features and Building General Features are in Table 5-8.

The consolidated matrix, obtained by taking the geometric mean of the answers, were analyzed according to the AHP method and the criterion weights were found. The weight values and CR of the analysis of the building detail features, building spatial features, building environmental features and building general features are given in Table 9-12.

Table 5. Building Detail Features - Binary Comparison Matrix

C	1	2	3	4	5	6	7	8
1	**1**	0,42	1,91	4,37	0,76	0,30	0,49	1,88
2	2,36	**1**	2,33	4,97	1,42	0,54	0,55	2,84
3	0,52	0,43	**1**	2,89	0,49	0,25	0,35	2,06
4	0,23	0,2	0,35	**1**	0,2	0,23	0,23	0,34
5	1,31	0,71	2,06	4,89	**1**	0,41	0,55	2,54
6	3,35	1,86	3,97	4,27	2,47	**1**	1,19	3,53
7	2,06	1,83	2,86	4,31	1,82	0,84	**1**	3,00
8	0,53	0,35	0,49	2,94	0,39	0,28	0,33	**1**

Building Detail Features

Weighted geometric mean of participants

Consolidated Matrix

15 = k number of participants

8 = n number of criteria

1	1	2	3	4	5	6	7	8
1	**1**	1/9	9	9	1/9	1/7	6	6
2	9	**1**	9	9	6	7	9	9
3	1/9	1/9	**1**	1/5	1/9	1/9	1/9	1/5
4	1/9	1/9	5	**1**	1/9	1/9	1/9	1/7
5	9	1/6	9	9	**1**	5	9	9
6	7	1/7	9	9	1/5	**1**	9	9
7	1/6	1/9	9	9	1/9	1/9	**1**	9
8	1/6	1/9	5	7	1/9	1/9	1/9	**1**

2	1	2	3	4	5	6	7	8
1	**1**	1/5	7	7	3	3	5	3
2	5	**1**	7	7	5	3	3	3
3	1/7	1/7	**1**	3	1/3	1/3	1	1
4	1/7	1/7	1/3	**1**	1/3	1/3	1/3	1/3
5	1/3	1/5	3	3	**1**	1/3	1	1
6	1/3	1/3	3	3	3	**1**	3	1
7	1/5	1/3	1	3	1	1/3	**1**	1
8	1/3	1/3	1	3	1	1	1	**1**

3	1	2	3	4	5	6	7	8
1	**1**	1/7	6	6	1/6	1/7	1/8	6
2	7	**1**	8	8	1/6	1/7	1/7	9
3	1/6	1/8	**1**	3	1/9	1/9	1/9	8
4	1/6	1/8	1/3	**1**	1/9	1/9	1/9	1/3
5	6	6	9	9	**1**	1/4	1/6	5
6	7	7	9	9	4	**1**	1/7	9
7	8	7	9	9	6	7	**1**	9
8	1/6	1/9	1/8	3	1/5	1/9	1/9	**1**

4	1	2	3	4	5	6	7	8
1	**1**	1/5	7	6	1/3	1/7	3	4
2	5	**1**	3	5	2	1/3	4	2
3	1/7	1/3	**1**	7	1/3	1/3	2	4
4	1/6	1/5	1/7	**1**	1/4	1/5	1/4	1/2
5	3	1/2	3	4	**1**	1/5	1/4	3
6	7	3	3	5	5	**1**	5	5
7	1/3	1/4	1/2	4	4	1/5	**1**	1/2
8	1/4	1/2	1/4	2	1/3	1/5	2	**1**

5	1	2	3	4	5	6	7	8
1	**1**	1/3	3	5	1/4	1/3	1/4	2
2	3	**1**	1/3	3	1/4	1/3	1/4	4
3	1/3	3	**1**	4	1/4	1/4	1/4	1/3
4	1/5	1/3	1/4	**1**	1/4	1/4	1/4	1/4
5	4	4	4	4	**1**	1/3	1/4	1/3
6	3	3	4	4	3	**1**	1/4	4
7	4	4	4	4	4	4	**1**	3
8	1/2	1/4	3	4	3	1/4	1/3	**1**

6	1	2	3	4	5	6	7	8
1	**1**	3	1/5	2	5	1/7	1/6	1/4
2	1/3	**1**	1/5	5	5	1/6	1/6	1/5
3	5	5	**1**	6	4	1/7	1/7	4
4	1/2	1/5	1/6	**1**	1/5	1/5	1/5	1/5
5	1/5	1/5	1/4	5	**1**	1/5	1/5	5
6	7	6	7	5	5	**1**	5	5
7	6	6	7	5	5	1/5	**1**	5
8	4	5	1/4	5	1/5	1/5	1/5	**1**

7	1	2	3	4	5	6	7	8
1	**1**	1/6	6	6	6	6	1/5	4
2	6	**1**	3	3	6	5	1/4	5
3	1/6	1/3	**1**	5	4	3	1/5	4
4	1/6	1/3	1/5	**1**	1/4	1/4	1/4	1/4
5	1/6	1/6	1/4	4	**1**	1/5	1/4	4
6	1/6	1/5	1/3	4	5	**1**	1/4	4
7	5	4	5	4	4	4	**1**	4
8	1/4	1/5	1/4	4	1/4	1/4	1/4	**1**

8	1	2	3	4	5	6	7	8
1	**1**	2	1/3	9	2	1/5	1/7	2
2	1/2	**1**	1/4	9	3	1/4	1/5	2
3	3	4	**1**	3	4	1/5	1/4	2
4	1/9	1/9	1/3	**1**	1/5	1/5	1/5	1/5
5	1/2	1/3	1/4	5	**1**	1/4	1/4	3
6	5	4	5	5	4	**1**	1/5	5
7	7	5	4	5	4	5	**1**	7
8	1/2	1/2	1/2	5	1/3	1/5	1/7	**1**

9	1	2	3	4	5	6	7	8
1	**1**	7	5	5	5	1/3	1/5	5
2	1/7	**1**	5	3	5	1/7	1/5	3
3	1/5	1/5	**1**	5	1/5	1/5	1/5	5
4	1/5	1/3	1/5	**1**	1/7	1/7	1/7	1/7
5	1/5	1/5	5	7	**1**	1/7	5	3
6	3	7	5	7	7	**1**	1/3	3
7	5	5	5	7	1/5	3	**1**	3
8	1/5	1/3	1/5	7	1/3	1/3	1/3	**1**

10	1	2	3	4	5	6	7	8
1	**1**	1/7	5	8	1/7	1/7	1/9	1/8
2	7	**1**	7	8	1/9	1/8	1/9	6
3	1/5	1/7	**1**	8	1/9	1/9	1/8	5
4	1/8	1/8	1/8	**1**	1/9	1/8	1/9	1/4
5	7	9	9	9	**1**	1/9	1/8	5
6	7	8	9	8	9	**1**	6	9
7	9	9	8	9	8	1/6	**1**	9
8	8	1/6	1/5	4	1/5	1/9	1/9	**1**

11	1	2	3	4	5	6	7	8
1	**1**	1/3	1/3	1	1/3	1/5	3	1/3
2	3	**1**	3	5	1	1/3	3	1
3	3	1/3	**1**	3	1/3	1/3	5	1
4	1	1/5	1/3	**1**	1/5	1/5	1	1/3
5	3	1	3	5	**1**	1	3	1
6	5	3	3	5	1	**1**	5	3
7	1/3	1/3	1/5	1	1/3	1/5	**1**	1/3
8	3	1	1	3	1	1/3	3	**1**

12	1	2	3	4	5	6	7	8
1	**1**	1/9	1/5	7	7	1/5	1/9	7
2	9	**1**	9	9	9	9	1/9	9
3	5	1/9	**1**	5	5	1/5	1/9	5
4	1/7	1/9	1/5	**1**	1/3	5	1/9	1/5
5	1/7	1/9	1/5	3	**1**	3	1/9	3
6	5	1/9	5	1/5	1/3	**1**	1/9	1/5
7	9	9	9	9	9	9	**1**	9
8	1/7	1/9	1/5	5	1/3	5	1/9	**1**

13	1	2	3	4	5	6	7	8
1	**1**	1/3	1/3	1	1/3	1/5	3	1/3
2	3	**1**	3	5	1	1/3	3	1
3	3	1/3	**1**	3	1/3	1/3	5	1
4	1	1/5	1/3	**1**	1/5	1/5	1	1/3
5	3	1	3	5	**1**	1	3	1
6	5	3	3	5	1	**1**	5	3
7	1/3	1/3	1/5	1	1/3	1/5	**1**	1/3
8	3	1	1	3	1	1/3	3	**1**

14	1	2	3	4	5	6	7	8
1	**1**	1/3	3	4	1/3	1/2	1/5	3
2	3	**1**	1/2	5	1/2	1/2	1/2	2
3	1/3	2	**1**	3	1/2	1/2	1/3	2
4	1/4	1/5	1/3	**1**	1/3	1/3	1/3	2
5	3	2	2	3	**1**	1/2	1/2	2
6	2	2	2	3	2	**1**	1/2	3
7	5	2	3	3	2	2	**1**	4
8	1/3	1/2	1/2	1/2	1/2	1/3	1/4	**1**

15	1	2	3	4	5	6	7	8
1	**1**	3	3	3	1/3	1/7	1/3	5
2	1/3	**1**	3	1	1/3	1/7	1/3	5
3	1/3	1/3	**1**	1/3	1/7	1/7	1/7	3
4	1/3	1	3	**1**	1/4	1/7	1/5	3
5	3	3	7	4	**1**	1/5	1/3	5
6	7	7	7	7	5	**1**	4	7
7	3	3	7	5	3	1/4	**1**	8
8	1/5	1/5	1/3	1/3	1/5	1/7	1/8	**1**

Table 6. Building Spatial Features - Binary Comparison Matrix

Building Spatial Features

Weighted geometric mean of participants

Consolidated Matrix

15 = k number of participants

7 = n number of criteria

C	1	2	3	4	5	6	7
1	**1**	1,78	0,99	1,6	4,4	2,51	0,88
2	0,56	**1**	0,72	1,35	4,01	1,5	0,79
3	1,01	1,4	**1**	1,9	3,24	1,48	0,91
4	0,62	0,74	0,53	**1**	3,16	1,18	0,75
5	0,23	0,25	0,31	0,32	**1**	0,36	0,21
6	0,4	0,67	0,68	0,85	2,76	**1**	0,3
7	1,14	1,26	1,1	1,34	4,76	3,3	**1**

1	1	2	3	4	5	6	7
1	**1**	7	7	1/7	3	3	5
2	1/7	**1**	1/8	1/8	3	3	3
3	1/7	8	**1**	1/4	7	3	3
4	7	8	4	**1**	5	5	5
5	1/3	1/3	1/7	1/5	**1**	5	1/4
6	1/3	1/3	1/3	1/5	1/5	**1**	1/4
7	1/5	1/3	1/3	1/5	4	4	**1**

2	1	2	3	4	5	6	7
1	**1**	3	3	1/3	3	1/3	3
2	1/3	**1**	1	1	1	1	1
3	1/3	1	**1**	1	1	1/3	1/3
4	3	1	1	**1**	5	5	5
5	1/3	1	1	1/5	**1**	1	1
6	3	1	3	1/5	1	**1**	1
7	1/3	1	3	1/5	1	1	**1**

3	1	2	3	4	5	6	7
1	**1**	8	1/8	1/7	8	8	1/7
2	1/8	**1**	1/9	1/7	8	5	1/5
3	8	9	**1**	8	9	9	8
4	7	7	1/8	**1**	9	8	8
5	1/8	1/8	1/9	1/9	**1**	1/9	1/9
6	1/8	1/5	1/9	1/8	9	**1**	1/7
7	7	5	1/8	1/8	9	7	**1**

4	1	2	3	4	5	6	7
1	**1**	4	2	2	9	6	3
2	1/4	**1**	1/4	1/3	9	1/2	2
3	1/2	4	**1**	2	9	1/2	3
4	1/2	3	1/2	**1**	9	1/2	4
5	1/9	1/9	1/9	1/9	**1**	1/9	1/9
6	1/6	2	2	2	9	**1**	3
7	1/3	1/2	1/3	1/4	9	1/3	**1**

5	1	2	3	4	5	6	7
1	**1**	2	1/4	3	3	4	1/3
2	1/2	**1**	1/4	2	3	2	1/4
3	4	4	**1**	4	1/3	3	3
4	1/3	1/2	1/4	**1**	2	2	1/4
5	1/3	1/3	3	1/2	**1**	1/2	1/4
6	1/4	1/2	1/3	1/2	2	**1**	1/4
7	3	4	1/3	4	4	4	**1**

6	1	2	3	4	5	6	7
1	**1**	3	3	3	3	3	3
2	1/3	**1**	1/3	4	4	4	4
3	1/3	3	**1**	5	5	5	5
4	1/3	1/4	1/5	**1**	7	1/6	1/6
5	1/3	1/4	1/5	1/7	**1**	1/6	1/6
6	1/3	1/4	1/5	6	6	**1**	1/6
7	1/3	1/4	1/5	6	6	6	**1**

7	1	2	3	4	5	6	7
1	**1**	8	7	5	5	5	1
2	1/8	**1**	1/4	1/4	5	1/5	1/8
3	1/7	4	**1**	1/5	4	1/4	1/8
4	1/5	4	5	**1**	6	6	8
5	1/5	1/5	1/4	1/6	**1**	1/6	1/8
6	1/5	5	4	1/6	6	**1**	1/8
7	1	8	8	1/8	8	8	**1**

8	1	2	3	4	5	6	7
1	**1**	2	1/5	1/5	3	3	1/5
2	1/2	**1**	1/5	4	2	2	1/5
3	5	5	**1**	4	3	4	5
4	5	1/4	1/4	**1**	4	3	1/5
5	1/3	1/2	1/3	1/4	**1**	1/4	1/4
6	1/3	1/2	1/4	1/3	4	**1**	1/5
7	5	5	1/5	5	4	5	**1**

9	1	2	3	4	5	6	7
1	**1**	5	5	5	5	5	1/7
2	1/5	**1**	7	7	5	3	7
3	1/5	1/7	**1**	3	5	5	1/7
4	1/5	1/7	1/3	**1**	1/5	1/5	1/7
5	1/5	1/5	1/5	5	**1**	5	1/3
6	1/5	1/3	1/5	5	1/5	**1**	1/7
7	7	1/7	7	7	3	7	**1**

10	1	2	3	4	5	6	7
1	**1**	1/8	1/8	7	9	8	1/7
2	8	**1**	7	7	9	7	1/4
3	8	1/7	**1**	5	6	7	1/6
4	1/7	1/7	1/5	**1**	7	8	1/8
5	1/9	1/9	1/6	1/7	**1**	1/7	1/9
6	1/8	1/7	1/7	1/8	7	**1**	1/9
7	7	4	6	8	9	9	**1**

11	1	2	3	4	5	6	7
1	**1**	3	3	3	5	1	1
2	1/3	**1**	3	3	5	1	1
3	1/3	1/3	**1**	3	5	1/3	1/3
4	1/3	1/3	1/3	**1**	1/3	1/5	1/5
5	1/5	1/5	1/5	3	**1**	1/5	1/5
6	1	1	3	5	5	**1**	3
7	1	1	3	5	5	1/3	**1**

12	1	2	3	4	5	6	7
1	**1**	1/7	1/9	5	5	1/7	7
2	7	**1**	1/9	7	7	7	7
3	9	9	**1**	9	9	9	9
4	1/5	1/7	1/9	**1**	5	1/7	1/5
5	1/5	1/7	1/9	1/5	**1**	1/7	1/7
6	7	1/7	1/9	7	7	**1**	1/7
7	1/7	1/7	1/9	5	7	7	**1**

13	1	2	3	4	5	6	7
1	**1**	1/3	1/3	3	3	2	1/2
2	3	**1**	2	3	3	1/2	1/2
3	3	1/2	**1**	2	3	1/2	1/3
4	1/3	1/3	1/2	**1**	2	1/3	1/3
5	1/3	1/3	1/3	1/2	**1**	1/3	1/3
6	1/2	2	2	3	3	**1**	1/3
7	2	2	3	3	3	3	**1**

14	1	2	3	4	5	6	7
1	**1**	1/3	1/3	3	3	2	1/2
2	3	**1**	2	3	3	1/2	1/2
3	3	1/2	**1**	2	3	1/2	1/3
4	1/3	1/3	1/2	**1**	2	1/3	1/3
5	1/3	1/3	1/3	1/2	**1**	1/3	1/3
6	1/2	2	2	3	3	**1**	1/3
7	2	2	3	3	3	3	**1**

15	1	2	3	4	5	6	7
1	**1**	3	7	2	5	5	3
2	1/3	**1**	7	1/5	3	1/2	1/3
3	1/7	1/7	**1**	1/7	1/3	1/5	1/7
4	1/2	5	7	**1**	5	4	3
5	1/5	1/3	3	1/5	**1**	1/2	1/7
6	1/5	2	5	1/4	2	**1**	1/5
7	1/3	3	7	1/3	7	5	**1**

Table 7. Building Environmental Features - Binary Comparison Matrix

Building Environmental Features

Weighted geometric mean of participants

Consolidated Matrix

15 = k number of participants

5 = n number of criteria

C	1	2	3	4	5
1	**1**	0,62	0,6	0,23	0,3
2	1,6	**1**	1,28	0,59	0,49
3	1,67	0,78	**1**	0,47	0,66
4	4,3	1,71	2,13	**1**	2,12
5	3,29	2,03	1,52	0,47	**1**

1	1	2	3	4	5
1	**1**	7	7	1/7	1/5
2	1/7	**1**	1/5	5	5
3	1/7	5	**1**	3	5
4	7	1/5	1/3	**1**	5
5	5	1/5	1/5	1/5	**1**

2	1	2	3	4	5
1	**1**	3	1/3	1/3	1/5
2	1/3	**1**	1/3	1/3	1/5
3	3	3	**1**	1/5	1/5
4	3	3	5	**1**	1/3
5	5	5	5	3	**1**

3	1	2	3	4	5
1	**1**	1/7	1/8	1/9	1/8
2	7	**1**	1/7	1/9	1/6
3	8	7	**1**	1/7	8
4	9	9	7	**1**	9
5	8	6	1/8	1/9	**1**

4	1	2	3	4	5
1	**1**	1/5	5	1/7	1/4
2	5	**1**	8	1/4	5
3	1/5	1/8	**1**	1/6	1/7
4	7	4	6	**1**	7
5	4	1/5	7	1/7	**1**

5	1	2	3	4	5
1	**1**	1/3	1/4	1/3	1/4
2	3	**1**	3	3	3
3	4	1/3	**1**	1/3	1/3
4	3	1/3	3	**1**	3
5	4	1/3	3	1/3	**1**

6	1	2	3	4	5
1	**1**	3	1/4	1/6	1/5
2	1/3	**1**	1/5	1/5	1/5
3	4	5	**1**	1/5	5
4	6	5	5	**1**	5
5	5	5	1/5	1/5	**1**

7	1	2	3	4	5
1	**1**	5	1/4	1/5	1/4
2	1/5	**1**	1/4	1/4	1/4
3	4	4	**1**	5	1/4
4	5	4	1/5	**1**	1/5
5	4	4	4	5	**1**

8	1	2	3	4	5
1	**1**	1/4	1/4	1/3	1/4
2	4	**1**	5	1/3	1/4
3	4	1/5	**1**	1/3	1/4
4	3	3	3	**1**	1/4
5	4	4	4	4	**1**

9	1	2	3	4	5
1	**1**	9	3	5	3
2	1/9	**1**	3	1/3	1/3
3	1/3	1/3	**1**	3	1/5
4	1/5	3	1/3	**1**	5
5	1/3	3	5	1/5	**1**

10	1	2	3	4	5
1	**1**	1/7	1/6	1/8	1/9
2	7	**1**	7	5	4
3	6	1/7	**1**	5	6
4	8	1/5	1/5	**1**	7
5	9	1/4	1/6	1/7	**1**

11	1	2	3	4	5
1	**1**	1/3	1	1/5	1/7
2	3	**1**	3	1/3	1/7
3	1	1/3	**1**	1/3	1/7
4	5	3	3	**1**	1/5
5	7	7	7	5	**1**

12	1	2	3	4	5
1	**1**	1/5	7	1/9	7
2	5	**1**	1/7	1/7	1/9
3	1/7	7	**1**	1/9	7
4	9	7	9	**1**	9
5	1/7	9	1/7	1/9	**1**

13	1	2	3	4	5
1	**1**	1/5	1/3	1/5	1/5
2	5	**1**	5	3	1/3
3	3	1/5	**1**	1/5	1/5
4	5	1/3	5	**1**	4
5	5	3	5	1/4	**1**

14	1	2	3	4	5
1	**1**	1/5	1/3	1/5	1/5
2	5	**1**	5	3	1/3
3	3	1/5	**1**	1/5	1/5
4	5	1/3	5	**1**	4
5	5	3	5	1/4	**1**

15	1	2	3	4	5
1	**1**	1/3	1/5	1/5	1/3
2	3	**1**	3	1/5	1/3
3	5	1/3	**1**	1/3	1/3
4	5	5	3	**1**	1
5	3	3	3	1	**1**

Table 8. Building General Features - Binary Comparison Matrix

Building General Features

Weighted geometric mean of participants

Consolidated Matrix

15 = k number of participants

3 = n number of criteria

C	1	2	3
1	**1**	0,31	0,49
2	3,22	**1**	3,64
3	2,02	0,27	**1**

1	1	2	3
1	**1**	1/5	1/5
2	5	**1**	5
3	5	1/5	**1**

2	1	2	3
1	**1**	1/5	3
2	5	**1**	3
3	1/3	1/3	**1**

3	1	2	3
1	**1**	1/8	1/7
2	8	**1**	5
3	7	1/5	**1**

4	1	2	3
1	**1**	1/3	1/2
2	3	**1**	3
3	2	1/3	**1**

5	1	2	3
1	**1**	3	1/2
2	1/3	**1**	1/3
3	2	3	**1**

6	1	2	3
1	**1**	1/3	1/3
2	3	**1**	4
3	3	1/4	**1**

7	1	2	3
1	**1**	1/5	4
2	5	**1**	5
3	1/4	1/5	**1**

8	1	2	3
1	**1**	1/5	1/5
2	5	**1**	5
3	5	1/5	**1**

9	1	2	3
1	**1**	1/5	1/5
2	5	**1**	5
3	5	1/5	**1**

10	1	2	3
1	**1**	1/7	1/7
2	7	**1**	7
3	7	1/7	**1**

11	1	2	3
1	**1**	1/3	2
2	3	**1**	3
3	1/2	1/3	**1**

12	1	2	3
1	**1**	1/5	1/7
2	5	**1**	7
3	7	1/7	**1**

13	1	2	3
1	**1**	1/4	1/3
2	4	**1**	4
3	3	1/4	**1**

14	1	2	3
1	**1**	1/4	1/3
2	4	**1**	4
3	3	1/4	**1**

15	1	2	3
1	**1**	3	5
2	1/3	**1**	3
3	1/5	1/3	**1**

Table 9. AHP Result of Building Detail Features

Criteria	Weights	+/-
Number of Rooms	10,00 %	2,55 %
Building Area	15,92 %	3,52 %
Balcony Condition	7,29 %	2,12 %
En-suite Bathroom	3,19 %	1,29 %
Floor location	12,57 %	2,01 %
Building Age	25,03 %	6,23 %
Heating system	20,13 %	4,23 %
Elevator	5,87 %	1,67 %
		CR = 0,0252

As a result of the analysis of building detail features, the CR value was found to be 0,0252 and a consistent result was obtained. When the weights were examined, building age was found to be the most important criterion with 25,03%.

Table 10. AHP Result of Building Spatial Features

Criteria	Weights	+/-
Proximity to City Center	20,36 %	3,03%
Proximity to Educational Institution	14,53 %	2,01 %
Proximity to Health Center	18,16 %	3,37 %
Proximity to Main Road	12,04 %	1,98 %
Proximity to Worship Areas	4,19 %	0,72 %
Proximity to Parks and Gardens	9,55 %	1,96 %
Proximity to the Workplace	21,17 %	4,89 %
CR = 0,0121		

As a result of the analysis of building spatial features, the CR value was found to be 0,0121 and a consistent result was obtained. When the weights were examined, proximity to the workplace was found to be the most important criterion with 21,17%.

Table 11. AHP Result of Building Environmental Features

Criteria	Weights	+/-
Building Parking	8,51 %	0,92 %
Public Transport Stop	16,10 %	3,65 %
Being on the Site	14,71 %	1,67 %
Neighborhood	36,16 %	9,20 %
Building Facade / Landscape	24,53 %	5,79 %
		CR = 0,0174

As a result of the analysis of building environmental features, the CR value was found to be 0,0174 and a consistent result was obtained. When the weights were examined, neighborhood was found to be the most important criterion with 36,16%.

Table 12. AHP Result of Building General Features

Criteria	Weights	+/-
Building Detail Features	14,75 %	4,03 %
Building Spatial Features	62,61 %	17,09 %
Building Environmental Features	22,64 %	6,18 %
		CR = 0,0797

Also, the analysis of building general features, the CR value was found to be 0,0797 and a consistent result was obtained. When the weights were examined, building spatial features was found to be the most important criterion with 62,61%. Building environmental features are 22.64% and building detail features are 14.75% rate was found to be significant.

4. Discussion

The AHP weights were proportioned as a percentage and the importance of 20 criteria in house selection was determined for discussing the sub-criteria. The importance weights of the criteria of house selection are given in Table 13.

Table 13. Criteria Weights in Housing Selection

No	Criteria	Weights
1	Proximity to the Workplace	13,25 %
2	Proximity to City Center	12,75 %
3	Proximity to Health Center	11,37 %
4	Proximity to Educational Institution	9,10 %
5	Neighborhood	8,19 %
6	Proximity to Main Road	7,54 %
7	Proximity to Parks and Gardens	5,98 %
8	Building Facade / Landscape	5,55 %
9	Building Age	3,69 %
10	Public Transport Stop	3,64 %
11	Being on the Site	3,33 %
12	Heating system	2,97 %
13	Proximity to Worship Areas	2,63 %
14	Building Area	2,35 %
15	Building Parking	1,93 %
16	Floor location	1,85 %
17	Number of Rooms	1,48 %
18	Balcony Condition	1,08 %
19	Elevator	0,87 %
20	En-suite Bathroom	0,47 %

When the importance weights of 20 criteria were examined, it was found that proximity to the workplace was the most important criterion with 13,25%. Proximity to the city center by 12.75%, to health centers by 11.37%, to educational institutions by 9.10%, to the neighborhood 8.19%, to the main road by 7.54%, to parks and gardens by 5%, 98%, Building Facade / View 5.55%, building age 3.69%, public transport stops 3.64%, being in the complex 3.33%, heating system 2.97%, proximity to places of worship 2.63%, flat size 2.35%, building parking 1.93%, 1.85% on which floor it is located, 1.48% number of rooms, 1.08% balcony status, 0.87% elevator and en-suite bathroom 0.47% rate was found to be significant.

In the study, the criteria were analyzed in groups, unlike the studies of Alkan and Durduran [3] and Tabar [24] (2020). The study shows similar characteristics with the study of Bozdağ and Ertunç [25], in which the criteria are grouped and analyzed. However, the use of a large number of decision makers in the study is the most important part that distinguishes the study from other studies.

5. Conclusion

In this study, 20 criteria affecting the house selection were examined in 3 different groups. These criteria were analyzed by the AHP method, which is one of the multi criteria decision making. Relative importance levels were obtained by creating pairwise comparison matrix of the criteria. The use of more than one decision maker or different decision makers in the analysis caused the CR value to be low and the consistency ratio to increase. Since subjective results will be obtained in analyzes made with a single decision maker, the study has generally reached an objective result. The study can be made more effective by increasing or decreasing the decision makers and criteria, or decision makers with different characteristics and used.

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Author contributions

Aslan Cihat Başara: Conceptualization, Methodology, Software, Data Supply, Data Curation, Analyze, Writing-Original Draft Preparation, Validation, Visualization. **Yasemin Sisman:** Data Supply, Writing-Original Draft Preparation, Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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