

# **Bulanık Analitik Hiyerarşik Süreç Ağırlıkları ile Nominal Değer Belirleme**

**Determination of Nominal Value by Fuzzy  
Analytic Hierarchic Process (AHP) Weights**



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## **Overview**

- \* **Introduction**
- \* **Methods**
- \* **Application**
- \* **Mapping**
- \* **Result and Conclusion**




# Decision Making




Information = Good Decision

JUST A MINUTE... WHY YES!! APPARENTLY I AM THE DECISION MAKER FOR THE COMPANY!!


All the people are decision makers, as a basis.



# Decision Making



When the assessment of many criteria is the case in a problem of decision-making, such decision-making circumstances are examined under multi-criteria decision-making model.



## Determination of Nominal Value

- \* Number of the factors that affect the real-estate value cannot be limited definitely. While an assessment operation to be performed on the location basis, a "nominal" value may be created per each real estate by combining the factors that affect the real estate.

$$N_i = \sum_{j=1}^k (P_{ji} * w_j)$$



## Fuzzy Analytic Hierarchic Process (Fuzzy AHP)

- \* Fuzzy AHP, which is one of the techniques used to solve the multi-criteria decision-making on the problems, is a multi-criteria fuzzy decision making method that supports the qualitative and quantitative and sub criterions grant the decision simultaneously.
- \* Fuzzy AHP is a suitable approach to the solution of the decision-making problems that contain blur or verbal uncertainty by using fuzzy scales with low, medium and high values.



## Fuzzy importance scale in fuzzy AHP

Pairwise comparison preferences	Importance scale	Correlations of the importance scale
Equally important	(1,1,1)	(1,1,1)
Intermediate	(1,2,3)	(1/3,1/2,1)
Little more important	(2,3,4)	(1/4,1/3,1/2)
Intermediate	(3,4,5)	(1/5,1/4,1/3)
More important	(4,5,6)	(1/6,1/5,1/4)
Intermediate	(5,6,7)	(1/7,1/6,1/5)
Much more important	(6,7,8)	(1/8,1/7,1/6)
Intermediate	(7,8,9)	(1/9,1/8,1/7)
Highly important	(8,9,9)	(1/9,1/9,1/8)



## Fuzzy AHP to the Chang (1992) method

**Step 1: M widened analysis value matrix is obtained by using pairwise comparison.**

$$M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m; \quad i = 1, 2, \dots, n$$

**Step 2: Fuzzy artificial greatness value may be described as:**

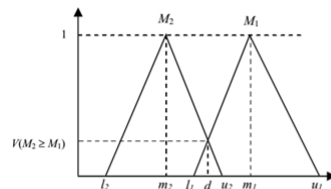
$$S_i = \sum_{j=1}^m M_{g_i}^j \otimes \left[ \sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j \right]^{-1}$$



## Fuzzy AHP to the Chang (1992) method

**Step 3:**  $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$

probability level may be described as:



$$V = S_{M_2} \geq S_{M_1} = \begin{cases} 1 & ; \text{ if } m_2 \geq m_1 \\ 0 & ; \text{ if } l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2)(m_1 - l_1)} & ; \text{ in other cases} \end{cases}$$



## Fuzzy AHP to the Chang (1992) method

**Step 4: Finding the weight vector**

$$V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1) \text{ ve } (M \geq M_2) \text{ ve } \dots \text{ ve } (M \geq M_k)] \\ = \min V(M \geq M_i), i = 1, 2, \dots, k$$

$$d'(A_i) = \min V(S_i \geq S_k)$$


$$W' = (d'(A_1), d'(A_2), \dots, d'(A_n))^T$$



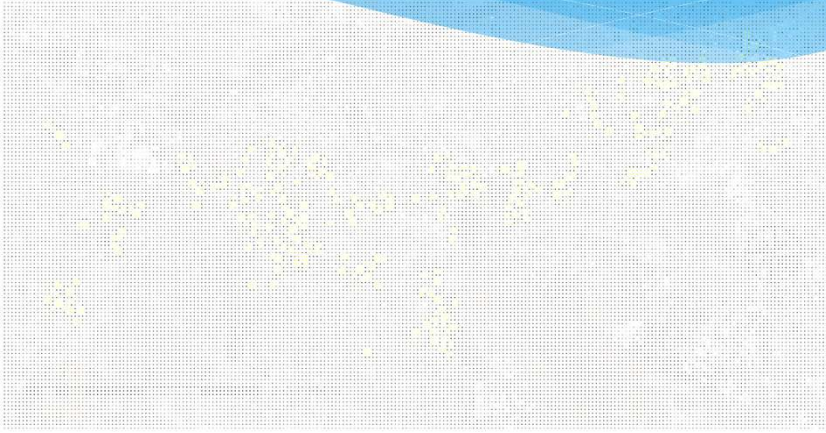
## Fuzzy AHP to the Chang (1992) method

**Step 5: Finding the normalized weight  
vector**


**W is not a fuzzy figure.**

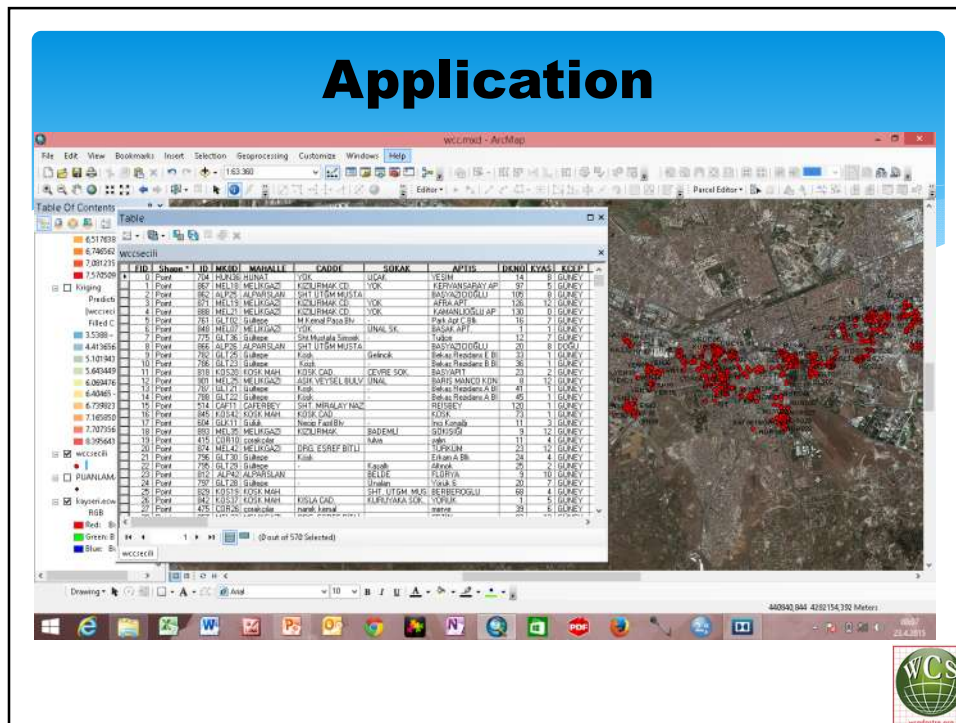


## Application



Melikgazi Town, location map of 570 houses





### Factor points according to the Saaty's AHP importance scale

S.N.	Factors	EML-1	EML-2	EML-3	EML-4	EML-5	EML-6	EML-7	EML-8	EML-9	EML-10	Average
1	Property's date	5	8	8	8	5	8	7	7	8	6	7
2	Property's exterior façade	8	8	7	8	9	9	8	9	9	7	8.2
3	Property's area	7	6	3	8	7	8	7	9	8	1	6.4
4	Number of rooms	5	8	8	8	7	6	8	9	1	1	6.1
5	Number of bathrooms	5	6	1	7	5	3	4	2	5	1	3.9
6	View	8	8	1	7	5	7	9	5	6	7	7.3
7	Whether in the complex	7	3	1	7	9	8	9	7	5	8	6.4
8	Car park	7	3	1	7	8	8	8	5	5	5	5.7
9	Security system	8	3	1	7	5	5	7	9	8	6	5.9
10	Road width of the main entrance	8	5	1	6	5	7	7	8	6	4	5.7
11	Floor of the property	6	6	5	7	7	8	8	8	8	4	6.7
12	Distance to school	8	8	3	6	8	7	6	7	5	3	6.1
13	Construction quality of exterior	9	8	1	8	8	8	9	8	7	5	7.1
14	Heating type	6	8	3	7	8	7	9	9	5	4	6.6
15	Fuel type	6	6	3	7	5	8	8	9	4	4	6
16	Maintenance fee	5	8	1	6	8	8	6	8	3	2	5.5
17	Rental income	9	8	2	7	8	4	7	5	8	8	6.6
18	Distance to the city center	6	6	1	7	8	7	7	7	5	7	6.1
19	Distance to the shopping center	4	3	1	6	8	6	8	6	6	5	5.3
20	Topographical structure of the land	5	3	1	3	5	8	9	5	4	4	4.7

### Step 1: Matrix of M values of the first 10 factors according to the fuzzy importance scale

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
<b>Factors</b>	<b>KYAS</b>	<b>KCEPHE</b>	<b>KALAN</b>	<b>ODASAY</b>	<b>BANSAY</b>	<b>MANZARA</b>	<b>SIVON</b>	<b>OTOPARK</b>	<b>GÜVENLİK</b>	<b>BGYOLGEN</b>
C1 Property's date	1.00 1.00 1.00	0.25 0.33 0.50	1.00 2.00 3.00	1.00 2.00 3.00	4.00 5.00 6.00	1.00 1.00 1.00	1.00 2.00 3.00	2.00 3.00 4.00	2.00 3.00 4.00	3.00 4.00 5.00
C2 Property's exterior façade	2.00 3.00 4.00	1.00 1.00 1.00	3.00 4.00 5.00	3.00 4.00 5.00	5.00 6.00 7.00	2.00 3.00 4.00	3.00 4.00 5.00	4.00 5.00 6.00	3.00 4.00 5.00	4.00 5.00 6.00
C3 Property's area	0.33 0.50 1.00	0.20 0.25 0.33	1.00 1.00 1.00	1.00 1.00 1.00	3.00 4.00 5.00	0.33 0.50 1.00	1.00 1.00 1.00	1.00 2.00 3.00	1.00 2.00 3.00	1.00 2.00 3.00
C4 Number of rooms	0.33 0.50 1.00	0.20 0.25 0.33	1.00 1.00 1.00	1.00 1.00 1.00	3.00 4.00 5.00	0.33 0.50 1.00	1.00 1.00 1.00	1.00 2.00 3.00	1.00 2.00 3.00	1.00 2.00 3.00
C5 Number of bathrooms	0.17 0.20 0.25	0.14 0.17 0.20	0.20 0.25 0.33	0.20 0.25 0.33	1.00 1.00 1.00	0.17 0.20 0.25	0.20 0.25 0.33	0.25 0.33 0.50	0.25 0.33 0.50	0.25 0.33 0.50
C6 View	1.00 1.00 1.00	0.25 0.33 0.50	1.00 2.00 3.00	1.00 2.00 3.00	4.00 5.00 6.00	1.00 1.00 1.00	1.00 2.00 3.00	2.00 3.00 4.00	2.00 3.00 4.00	2.00 3.00 4.00
C7 Whether in the complex	0.33 0.50 1.00	0.20 0.25 0.33	1.00 1.00 1.00	1.00 1.00 1.00	3.00 4.00 5.00	0.33 0.50 1.00	1.00 1.00 1.00	1.00 2.00 3.00	1.00 2.00 3.00	1.00 2.00 3.00
C8 Car park	0.25 0.33 0.50	0.17 0.20 0.25	0.33 0.50 1.00	1.00 1.00 1.00	2.00 3.00 4.00	0.25 0.33 0.50	0.33 0.50 1.00	1.00 1.00 1.00	1.00 1.00 1.00	1.00 1.00 1.00
C9 Security system	0.25 0.33 0.50	0.20 0.25 0.33	0.33 0.50 1.00	0.33 0.50 1.00	2.00 3.00 4.00	0.25 0.33 0.50	0.33 0.50 1.00	1.00 1.00 1.00	1.00 1.00 1.00	1.00 1.00 1.00
C10 Road width of the main entrance	0.20 0.25 0.33	0.17 0.20 0.25	0.33 0.50 1.00	0.33 0.50 1.00	2.00 3.00 4.00	0.25 0.33 0.50	0.33 0.50 1.00	1.00 1.00 1.00	1.00 1.00 1.00	1.00 1.00 1.00



### Step 2: Fuzzy artificial greatness values

Sc1	35,25	50,33	65,50	0,0013	0,0017	0,0024	0,046	0,087	0,157
Sc2	61,00	80,00	99,00	0,0013	0,0017	0,0024	0,079	0,138	0,237
Sc3	20,20	28,75	38,33	0,0013	0,0017	0,0024	0,026	0,049	0,092
Sc4	20,20	27,75	36,33	0,0013	0,0017	0,0024	0,026	0,048	0,087
Sc5	5,13	6,35	8,78	0,0013	0,0017	0,0024	0,007	0,011	0,021
Sc6	32,25	48,33	64,50	0,0013	0,0017	0,0024	0,042	0,083	0,155
Sc7	20,20	28,75	38,33	0,0013	0,0017	0,0024	0,026	0,049	0,092
Sc8	13,25	16,70	22,75	0,0013	0,0017	0,0024	0,017	0,029	0,055
Sc9	12,62	16,25	22,83	0,0013	0,0017	0,0024	0,016	0,028	0,055
Sc10	12,53	16,12	22,58	0,0013	0,0017	0,0024	0,016	0,028	0,054
Sc11	20,87	29,25	38,33	0,0013	0,0017	0,0024	0,027	0,050	0,092
Sc12	20,12	28,58	37,83	0,0013	0,0017	0,0024	0,026	0,049	0,091
Sc13	32,25	48,33	64,50	0,0013	0,0017	0,0024	0,042	0,083	0,155
Sc14	20,20	28,75	38,33	0,0013	0,0017	0,0024	0,026	0,049	0,092
Sc15	19,12	27,58	36,83	0,0013	0,0017	0,0024	0,026	0,049	0,092
Sc16	12,53	16,12	22,58	0,0013	0,0017	0,0024	0,025	0,047	0,088
Sc17	20,20	28,75	38,33	0,0013	0,0017	0,0024	0,016	0,028	0,054
Sc18	20,12	28,58	37,83	0,0013	0,0017	0,0024	0,026	0,049	0,092
Sc19	12,52	16,08	21,83	0,0013	0,0017	0,0024	0,026	0,049	0,091
Sc20	6,70	9,52	15,08	0,0013	0,0017	0,0024	0,016	0,028	0,052
Σ	417,24	580,88	770,45				0,009	0,016	0,036
1/Σ	0,0024	0,0017	0,0013						





### Step 3: Intersection probability of the factors

Factors	V(M <sub>2</sub> M)	Sc1	Sc2	Sc3	Sc4	Sc5	Sc6	Sc7	Sc8	Sc9	Sc10	Sc11	Sc12	Sc13	Sc14	Sc15	Sc16	Sc17	Sc18	Sc19	Sc20
Property's date	Sc1	1.000	0.354	0.315	0.000	0.969	0.334	0.132	0.133	0.124	0.896	0.889	0.869	0.893	0.855	0.124	0.403	0.545	0.100	0.068	
Property's exterior façade	Sc2	0.604	1.000	0.126	0.081	0.000	0.580	0.126	0.000	0.000	0.000	0.127	0.115	0.580	0.126	0.092	0.000	0.126	0.115	0.000	0.000
Property's area	Sc3	1.000	1.000	0.972	0.000	1.000	1.000	0.577	0.570	0.562	1.000	0.996	1.000	1.000	0.969	0.562	1.000	0.996	0.545	0.231	
Number of rooms	Sc4	1.000	1.000	1.000	1.000	0.000	1.000	0.598	0.590	0.582	1.000	1.000	1.000	1.000	0.995	0.582	1.000	1.000	0.565	0.240	
Number of bathrooms	Sc5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
View	Sc6	1.000	1.000	0.997	0.561	0.000	0.597	0.189	0.189	0.181	0.604	0.589	1.000	0.997	0.565	0.181	0.597	0.589	0.159	0.000	
Whether in the complex	Sc7	1.000	1.000	1.000	0.972	0.000	1.000	0.577	0.570	0.562	1.000	0.996	1.000	1.000	0.969	0.562	1.000	0.996	0.545	0.231	
Car park	Sc8	1.000	1.000	1.000	1.000	0.178	1.000	1.000	0.980	0.974	1.000	1.000	1.000	1.000	1.000	0.974	1.000	1.000	0.971	0.605	
Security system	Sc9	1.000	1.000	1.000	1.000	0.215	1.000	1.000	1.000	0.994	1.000	1.000	1.000	1.000	1.000	0.994	1.000	1.000	0.992	0.630	
Road width of the main entrance	Sc10	1.000	1.000	1.000	1.000	0.221	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.636	
Floor of the property	Sc11	1.000	1.000	0.987	0.959	0.000	1.000	0.987	0.559	0.553	0.545	0.982	1.000	0.987	0.955	0.545	0.987	0.982	0.527	0.211	
Distance to school	Sc12	1.000	1.000	1.000	0.977	0.000	1.000	0.581	0.574	0.566	1.000	1.000	1.000	0.973	0.566	1.000	1.000	0.549	0.234		
Construction quality of exterior	Sc13	1.000	1.000	0.997	0.561	0.000	1.000	0.597	0.189	0.189	0.181	0.604	0.589	0.997	0.565	0.181	0.597	0.589	0.159	0.000	
Heating type	Sc14	1.000	1.000	1.000	0.972	0.000	1.000	1.000	0.577	0.570	0.562	1.000	0.996	1.000	0.969	0.562	1.000	0.996	0.545	0.231	
Fuel type	Sc15	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.613	0.605	0.598	1.000	1.000	1.000	1.000	0.598	1.000	1.000	0.582	0.267	
Main maintenance fee	Sc16	1.000	1.000	1.000	1.000	0.221	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.998	0.636	
Rental income	Sc17	1.000	1.000	1.000	0.972	0.000	1.000	1.000	0.577	0.570	0.562	1.000	0.996	1.000	0.969	0.562	1.000	0.996	0.545	0.231	
Distance to the city center	Sc18	1.000	1.000	1.000	0.977	0.000	1.000	1.000	0.591	0.574	0.566	1.000	1.000	1.000	0.973	0.566	1.000	0.549	0.234		
Distance to the shopping center	Sc19	1.000	1.000	1.000	1.000	0.223	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Topographical structure of the land	Sc20	1.000	1.000	1.000	0.694	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
<b>Min(V/M<sub>2</sub>M)</b>	<b>0.604</b>	1.000	0.126	0.081	0.000	0.580	0.126	0.000	0.000	0.000	0.127	0.115	0.580	0.126	0.092	0.000	0.126	0.115	0.000	0.000	3.798
<b>W</b>	<b>0.159</b>	<b>0.263</b>	<b>0.033</b>	<b>0.021</b>	<b>0.000</b>	<b>0.153</b>	<b>0.033</b>	<b>0.000</b>	<b>0.000</b>	<b>0.000</b>	<b>0.033</b>	<b>0.030</b>	<b>0.153</b>	<b>0.033</b>	<b>0.024</b>	<b>0.000</b>	<b>0.033</b>	<b>0.030</b>	<b>0.000</b>	<b>0.000</b>	<b>1.000</b>



### Step 4 and 5: Normalized weight vector and not normalized weight vector

Factor name	Code	Weight vector not normalized	Weight vector normalized
Property's date	Sc1	0.604	0.159
Property's exterior façade	Sc2	1.000	0.263
Property's area	Sc3	0.126	0.033
Number of rooms	Sc4	0.081	0.021
Number of bathrooms	Sc5	0.000	0.000
View	Sc6	0.580	0.153
Whether in the complex	Sc7	0.126	0.033
Car park	Sc8	0.000	0.000
Security system	Sc9	0.000	0.000
Road width of the main entrance	Sc10	0.000	0.000
Floor of the property	Sc11	0.127	0.033
Distance to school	Sc12	0.115	0.030
Construction quality of exterior	Sc13	0.580	0.153
Heating type	Sc14	0.126	0.033
Fuel type	Sc15	0.092	0.024
Maintenance fee	Sc16	0.000	0.000
Rental income	Sc17	0.126	0.033
Distance to the city center	Sc18	0.115	0.030
Distance to the shopping center	Sc19	0.000	0.000
Topographical structure of the land	Sc20	0.000	0.000
<b>Total</b>		<b>3.798</b>	<b>1.000</b>




## Examples of factor pointing

**Rental income**

Value (TL)	Point
≤ 200	1
≤ 300	2
≤ 400	3
≤ 500	4
≤ 600	5
≤ 800	6
≤ 1000	7
≤ 1250	8
≤ 1500	9
≤ 2000	10


**Property's exterior façade**

Value	Point
G-GB	10
B-D-GD	5
K	1



## NV points for the first 10 houses

ID	DKOD	District	Street	X	Y	Total point	NV (Fuzzy AHP)	NV2 (Av.Meth)
704	HUN36	HUNAT	Uçak Sok.	4287722.04	456003.09	161	9.271	8.184
775	GLT36	Gültepe	Sht.Mustafa Simeek Blv	4287618.07	456787.28	156	9.127	7.917
867	MEL18	MELIKGAZI	KIZILIRMAK CD.	4288467.00	458219.00	165	9.060	8.286
988	ANA13	Mevlana	Mehmet Akif Ersoy	4285447.90	461154.26	146	9.044	7.441
761	GLT02	Gültepe	M.Kemal Paşa Blv	4287043.85	456646.45	159	9.023	8.048
358	YEN21	YENIKOY	Susam Sok.	4287017.96	452254.88	144	9.023	7.397
415	ÇOR10	çorakpilar	Fulya Sok.	4287319.61	453927.76	149	8.941	7.622
1030	ANA19	Mevlana	75. Yil	4285771.22	461647.18	131	8.889	6.800
1027	ANA56	Mevlana	Mehmet Timucin	4286142.14	461621.12	135	8.875	6.956





## Results and Conclusion

- \* Questionnaire average points obtained from 10 realtors have been expressed not by the certain figures but by the linguistic variety under the fuzzy group logic due to fuzzy logic used.
- \* Nominal appraisal points obtained shall be multiplied by the average nominal unit price to be obtained from the area in order to calculate the estimated sales value.



## Results and Conclusion

- \* Different nominal value maps may be created by applying different interpolation techniques on the real-estate values obtained by using nominal appraisal method. Interpolation methods may be verified by using estimated errors (root mean square error, etc).
- \* Factor weights may also be used in the real-estate appraisal problems to be obtained by different decision-making methods (Fuzzy Entropy, Fuzzy Dematel).



