A MULTI-ATTRIBUTE DECISION MAKING MODEL FOR HOSPITAL LOCATION SELECTION

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INTRODUCTION

- Hospitals are important components of health systems and need for hospitals continues increasingly
  - population growth,
  - environmental factors brought about by modern life,
  - the increase in the rate of the elderly population
  - worldwide effective epidemics
- To meet the increase in demand and to reach targeted health indicators establishing new hospitals continues in Turkey.

HOSPITAL LOCATION SELECTION

- An improper location selection for a hospital will create a large monetary load like wise any location selection for any purpose.
- Besides, and more importantly an improper location selection for a hospital may cause loss of human lives.

- The fact remains that location selection for a hospital is a difficult decision that needs many factors to be considered.
  - Population, Centrality, The healthcare sector, Distance to the main roads, Cost, etc.

HOSPITAL LOCATION SELECTION

- In this study, a hybrid Multi-Attribute Decision Making model is proposed for hospital location selection
- In the proposed model importance of attributes are determined using Analytic Network Process method and evaluation of alternatives is carried out using PROMETHEE method.

- The proposed model applied for a public hospital location selection in Trabzon, Turkey.
  - alternatives were determined as counties of Trabzon
  - 14 attributes were used

LITERATURE REVIEW

Authors	Year	MADM Method	Alternatives
Sinuany-Stern et al.	1995	AHP-Mathematical Modelling	Specific areas
Wu et al.	2007a	AHP	Districts
Wu et al.	2007b	Fuzzy AHP	Districts
Onut et al.,	2008	ANP	Counties
Lin et al.,	2008	Fuzzy AHP	Districts
Wu et al.	2009	Fuzzy ANP	Districts
Vahidnia et al.	2009	Fuzzy AHP-GIS	Specific areas
Lin and Tsai	2009	ANP- TOPSIS	Cities
Aydın and Arslan	2010	Fuzzy AHP	Districts
Soltani and Marandi	2011	Fuzzy ANP-GIS	Specific areas

Authors	Year	MADM Method	Alternatives
Chatterjee and Muherjee	2013	AHP	Counties
Chiu and Tsai	2013	AHP	Counties
Kim et al.	2015	GIS	Specific areas
Şen and Demiral	2016	GRA-AHP	Specific areas
Şenvar et al.	2016	Hesitant Fuzzy TOPSIS	Specific areas
Eldemir and Onden	2016	AHP-GIS	Specific areas
Sen	2017	ARAS-Gray Values	Specific areas
Şahin et al.	2019	AHP	Counties

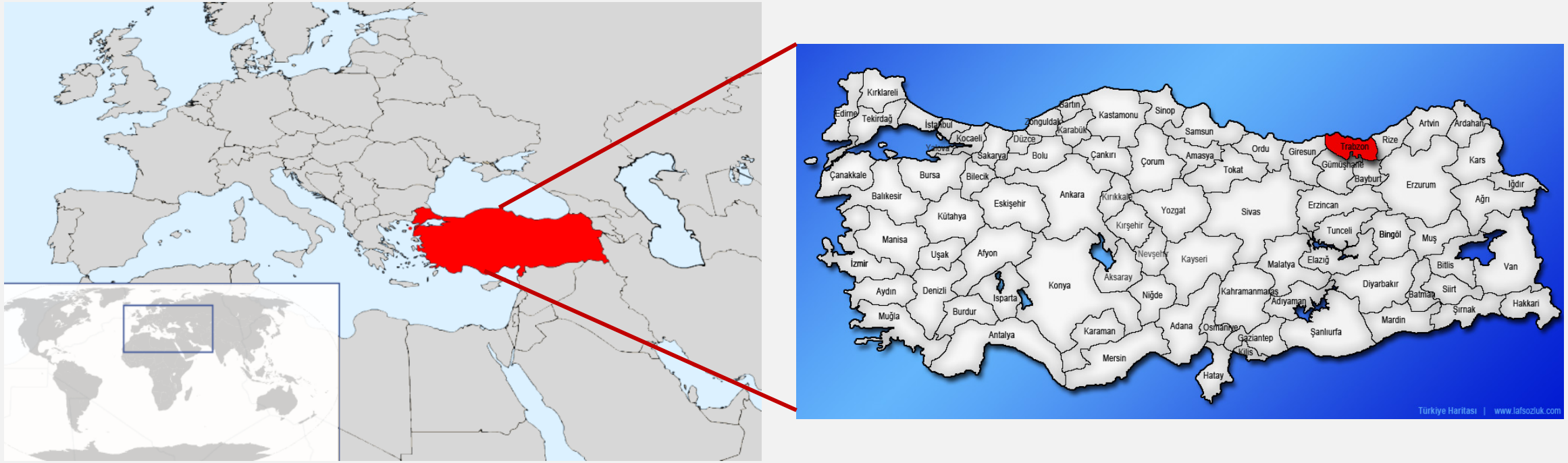
LITERATURE REVIEW

	Construction/ Lease Cost	Building rearrangement cost	Landscape cost	Labour cost /opportunity	Land cost/opportunity	Water and Electricity supply	Enlargement opportunity	Population	Population density	Population age structure	Level of income	Management objective	Rank of competitors	Policymaker's attitude	Pupilc support	Medical practice and pharmaceutical Sector	Hospital management sector
Wu et al.(2007a)	X			X	X			X	X	X		X	X	X		X	X
Wu et al(2007b)	X			X	X			X	X	X		X	X	X		X	X
Lin et al.(2008)				X	X			X	X	X		X	X	X		X	X
Önüt et al.(2008)	X			X	X			X	X		X	X	X	X		X	X
Lin and Tsai (2009)	X			X	X						X			X		X	X
Vahidnia et al. (2009)																	
Wu et al. (2009)	X			X	X			X	X	X		X	X	X		X	X
Aydın and Arslan (2010)	X	X	X						X		X						
Sinuany-Stern et al.(1995)					X				X								
Soltani and Marandi(2011)					X				X								
Chatterjee and Muherjee (2013)			X		X		X		X		X						
Chiu and Tsai (2013)	X				X			X	X				X			X	X
Kim et al.(2015)						X		X		X	X			X	X	X	
Sen and Demiral(2016)	X		X		X		X										
Şen (2017)	X		X		X		X										
Şahin et al.(2019)				X		X		X		X	X					X	

LITERATURE REVIEW

	Health sector and activities of competitors	Distance of competing hospitals	Regulation and standards of establishment of hospitals	Efforts to promote medical network	Centrality	Distance from main roads	Transport time to the hospital / traffic density	Proximity to settlements	City plan compliance	Proximity to noise sources	Public Transportation	Parking area	Significant change in market demand	Significant fluctuations in production costs	Significant changes in the financial market	Reduction local unemployment rate	Providing population distribution
Wu et al.(2007a)	X		X	X										X	X		
Wu et al.(2007b)	X		X	X										X	X		
Lin et al. (2008)	X		X	X									X	X	X		
Önüt et al.(2008)	X												X		X		
Lin and Tsai (2009)	X		X														
Vahidnia et al. (2009)						X	X			X							
Wu et al. (2009)			X	X										X	X		
Aydın and Arslan (2010)	X	X			X			X	X	X		X					
Sinuany-Stern et al.(1995)																X	X
Soltani and Marandi(2011)		X				X	X										
Chatterjee and Muherjee (2013)						X	X	X			X						
Chiu and Tsai (2013)	X					X			X		X	X					
Kim et al.(2015)	X					X					X						
Sen and Demiral(2016)										X	X	X					
Şen (2017)										X	X	X					
Şahin et al.(2019)	X	X				X				X	X		X				

CASE STUDY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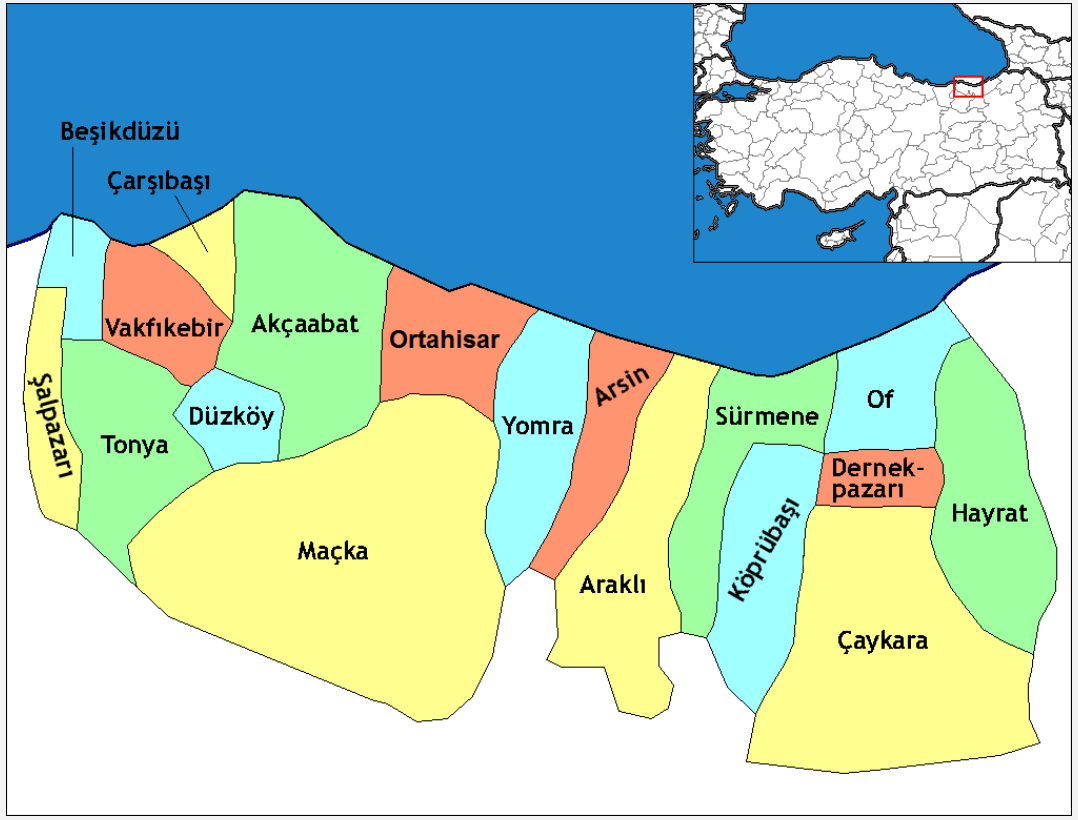
CASE STUDY



- 18 counties
  - Akçabat
  - Araklı
  - Arsin
  - Beşikdüzü
  - Çarşıbaşı
  - Çaykara
  - Dernekpazarı
  - Düzköy
  - Hayrat
  - Köprübaşı
  - Maçka
  - Of
  - Ortahisar
  - Sürmene
  - Şalpazarı
  - Tonya
  - Vakfıkebir
  - Yomra

STRUCTURING THE PROBLEM

EXPERTS

- 5 medical doctors (MDs)
- 5 authorities working at Trabzon Provincial Health Directorate
- 1 authority working at Trabzon Regional Directorate of Transport and Infrastructure

DETERMINATION OF ALTERNATIVES

- Counties were determined as alternatives
  - Uncountable lands will be accessible for a public hospital on a provincial basis
  - A new building will be more appropriate instead of changing an existing one to a hospital

STRUCTURING THE PROBLEM

DETERMINATION OF ATTRIBUTES

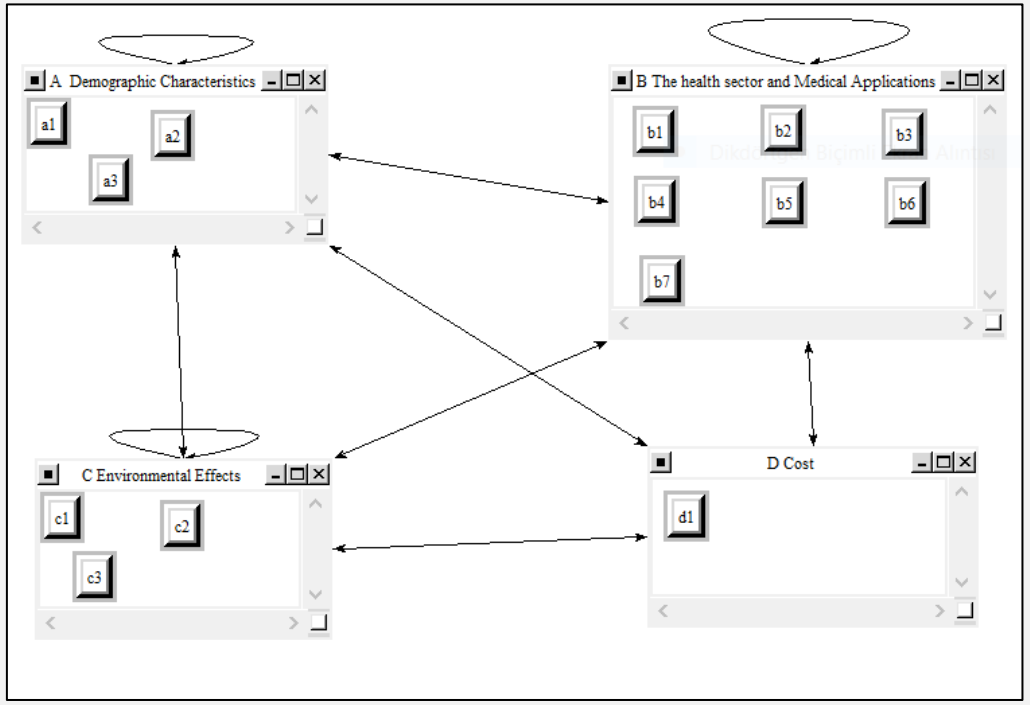
- Comprehensive literature review was conducted
- By discussing through the Delphi technique with experts, 14 attributes and 4 attribute categories were determined by consensus

Attribute categories	Attributes
A. Demographic characteristics	A1.Population
	A2.Population density
	A3.Centrality
B.The health sector and medical applications	B1.The number of family health centres (FHCs) in the county
	B2.The number of physicians in the FHCs
	B3.The number of public hospitals (PHs) in the county
	B4.Total number of beds in the county's PHs
	B5.The number of branch hospitals (BHs) in the county
	B6.Total number of beds in the county's BHs
	B7.The number of private hospitals in the county.
C. Environmental effects	C1. Distance to the main roads
	C2.Traffic congestion
	C3. Noise centre
D. Cost	D1. Land cost

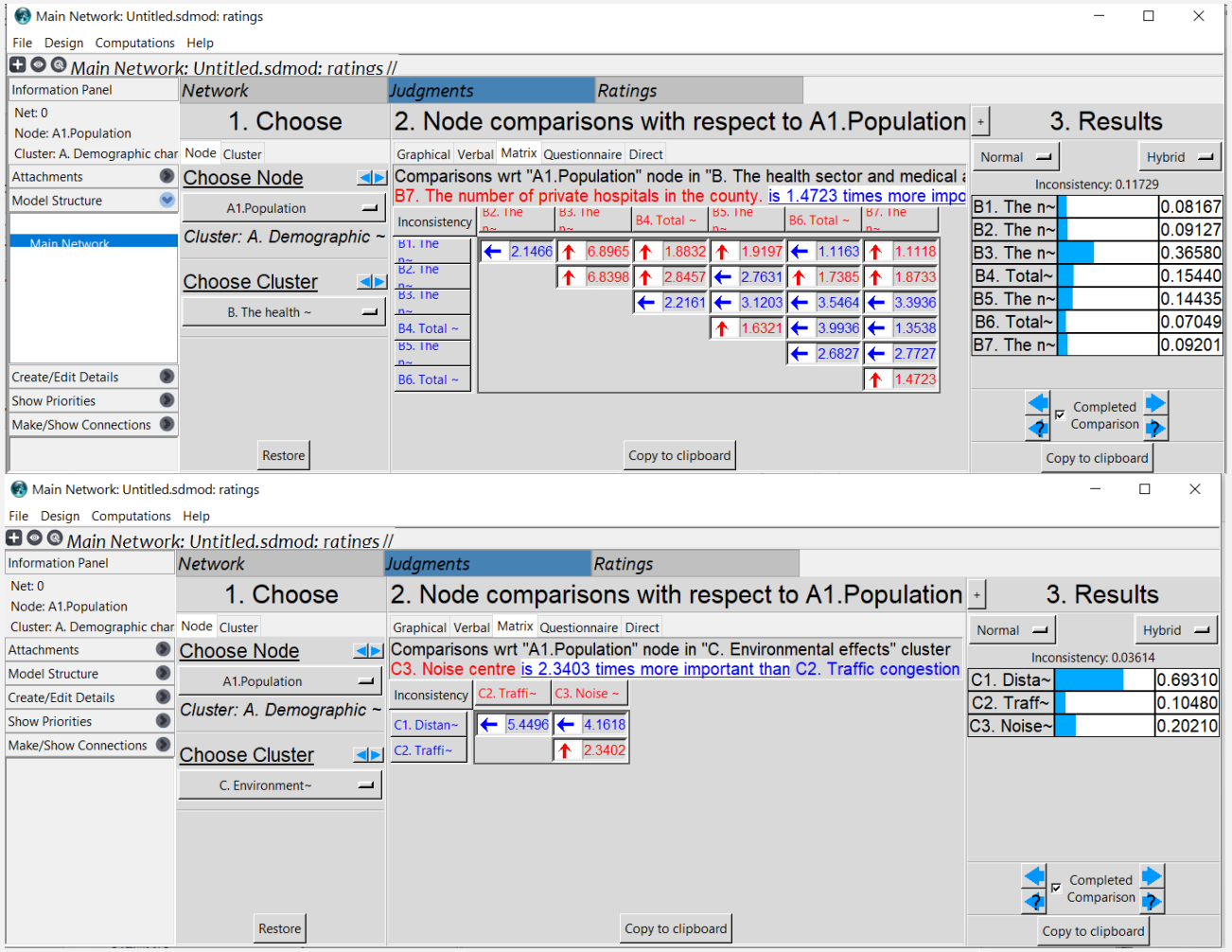
STRUCTURING THE PROBLEM

DEPENDENCIES BETWEEN ATTRIBUTES

	A1	A2	A3	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	D1
A1		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
A2											✓	✓		✓
A3						✓	✓	✓	✓	✓	✓	✓	✓	✓
B1	✓				✓									
B2	✓													
B3	✓						✓					✓		✓
B4	✓													
B5	✓								✓			✓		✓
B6	✓													
B7	✓													
C1	✓		✓							✓		✓	✓	✓
C2	✓										✓			
C3	✓													
D1	✓									✓	✓			



STRUCTURING THE PROBLEM



CONSTRUCTING THE DECISION MODEL

	Attribute	Priorities according to MD	Priorities according to civil authorities	Overall priorities
A	A1. Population	0.2909	0.2898	0.2891
	A3. Centrality	0.1856	0.1700	0.1780
	A2. Population density	0.0208	0.0409	0.0318
B	B3. Number of PHs	0.1160	0.1246	0.1198
	B5. Number of BHs	0.0469	0.0505	0.0496
	B4. Total number of beds in the PHs	0.0235	0.0346	0.0305
	B1. Number of FHCs	0.0316	0.0143	0.0203
	B7. Number of PHs	0.0179	0.0172	0.0180
	B6. Number of beds in the BHs	0.0128	0.0137	0.0135
	B2. Number of physicians in FHCs	0.0103	0.0085	0.0095
C	C1. Distance to main roads	0.1121	0.1101	0.1114
	C2. Traffic congestion	0.0594	0.0599	0.0598
	C3. Noise center	0.0148	0.0090	0.0112
D	D1. Land cost	0.0574	0.0570	0.0572

CONSTRUCTING THE DECISION MODEL

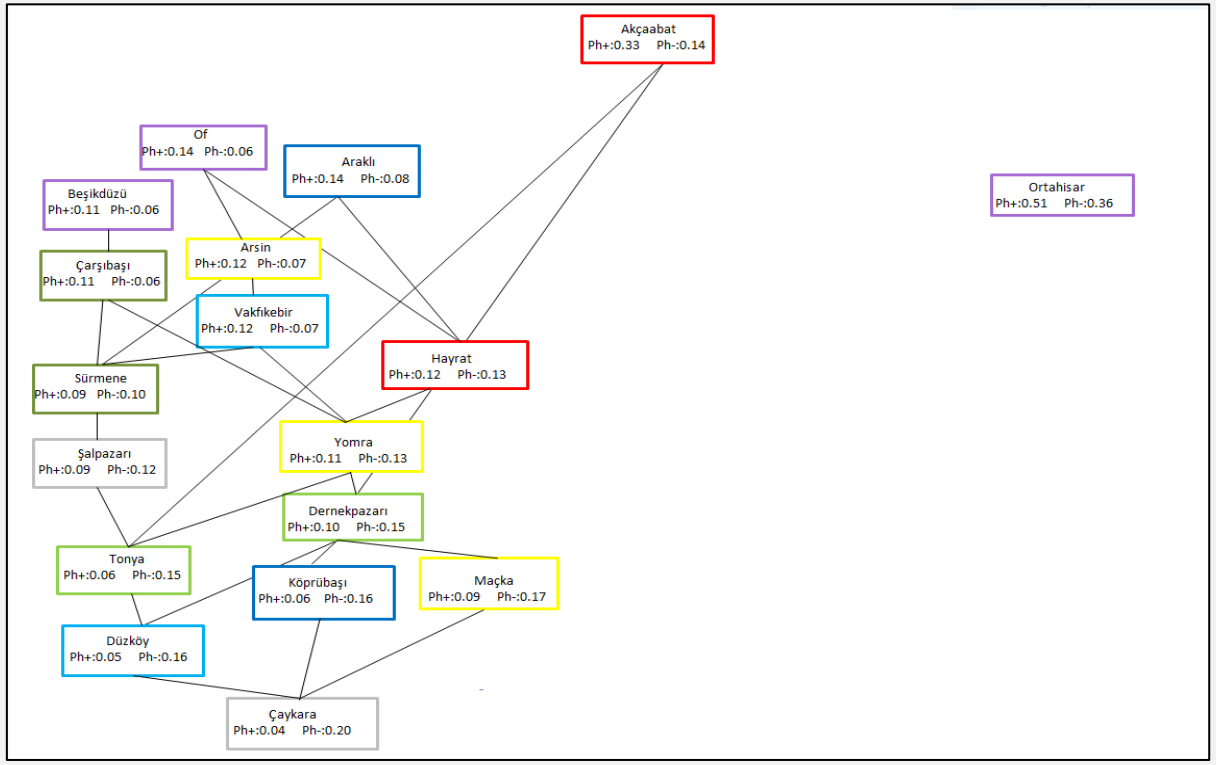
	A1	A2	A3	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	D1
Unit	(person)	(centrality)	(person/m^2)	(FHC)	(physician)	(public hospital)	(bed)	(branch hospital)	(bed)	(private hospital)	(km)	(0.100)	(0.100)	(TL)
Akçabat	115939	309.1707	141993.8774	13	33	1	221	0	0	2	0	87	0.1333	700000
Araklı	47960	103.3621	71817.9022	1	14	1	106	0	0	0	0	44	0.8836	900000
Arsin	28208	179.6688	64934.4800	2	10	1	5	0	0	0	0	42	1.4013	550000
Beşikdüzü	21870	260.3571	44015.9544	1	6	0	0	0	0	0	0	40	0.7143	800000
Çarşıbaşı	15596	236.3030	39632.4214	2	5	0	0	0	0	0	0	41	0.0000	350000
Çaykara	13854	24.1359	25351.2921	3	4	1	15	1	88	0	26	28	0.0000	400000
Dernekpazarı	3803	42.7303	18458.3615	1	1	0	0	0	0	0	18	19	0.0000	500000
Düzköy	14527	116.2160	29889.7561	3	5	1	10	0	0	0	28	19	0.0000	500000
Hayrat	7631	31.2746	21138.9758	2	3	0	0	0	0	0	11	19	0.0000	250000
Köprübaşı	4940	26.1376	20451.7782	1	2	1	10	0	0	0	14	22	0.0000	1000000
Maçka	24232	26.1968	43320.2633	2	6	0	0	1	110	0	26	38	0.1622	700000
Of	42405	164.3605	58101.9159	2	11	1	79	0	0	0	0	47	0.1938	750000
Ortahisar	314246	67.9010	332203.9963	66	98	2	999	2	430	2	0	98	0.0983	7000000
Sürmene	10903	65.6807	38769.7518	2	8	1	61	0	0	0	0	42	0.2711	1000000
Şalpazarı	26421	164.1056	37276.0245	1	5	1	10	0	0	0	16	22	0.0000	650000
Tonya	15217	86.4602	28489.9815	2	5	1	5	0	0	0	20	23	0.5114	600000
Vakfıkebir	26636	188.9078	49459.6786	3	7	1	132	0	0	0	0	46	0.0000	600000
Yomra	32.394	161.970	77112.6864	4	10	1	616	0	0	0	0	71	0.3750	1250000

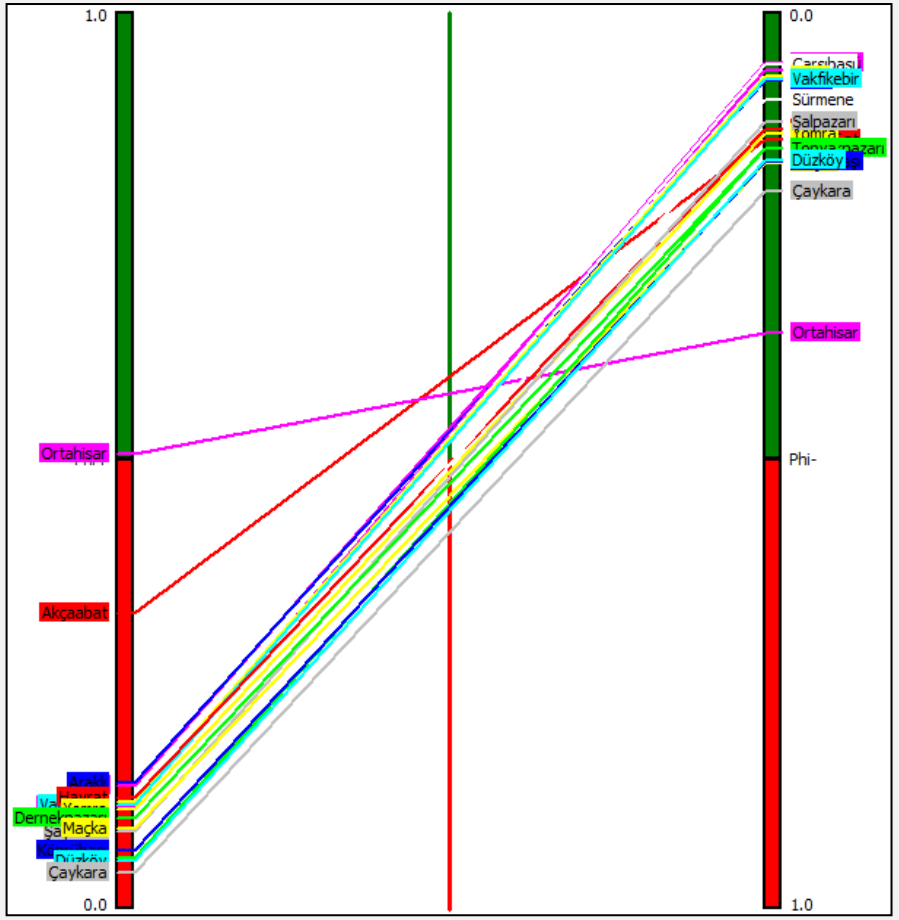
CONSTRUCTING THE DECISION MODEL

Attributes	Preference Function	Indifference Threshold (q)	Preference Threshold (p)
A1. Population	V shape	X	140707,03
A2. Population density	V shape	X	172,5050
A3. Centrality	Linear	85107,3009	143940,1672
B1. Number of FHCs	V shape	X	28,47
B2. Number of physicians in FHCs	Linear	5,00	43,26
B3. Number of PHs	Level	0,56	1,30
B4. Total number of beds in the PHs	Linear	50,00	250,00
B5. Number of BHs	Level	0,66	1,07
B6. Number of beds in the BHs	V shape	X	250
B7. Number of PHs	Level	0,81	1,23
C1. Distance to main roads	V shape	X	14,00
C2. Traffic congestion	Linear	21,35	45,93
C3. Noise center	Linear	0,2539	0,5777
D1. Land cost	Linear	500000	1500000

ANALYZING THE PROPLEM

- PROMETHEE I RESULTS



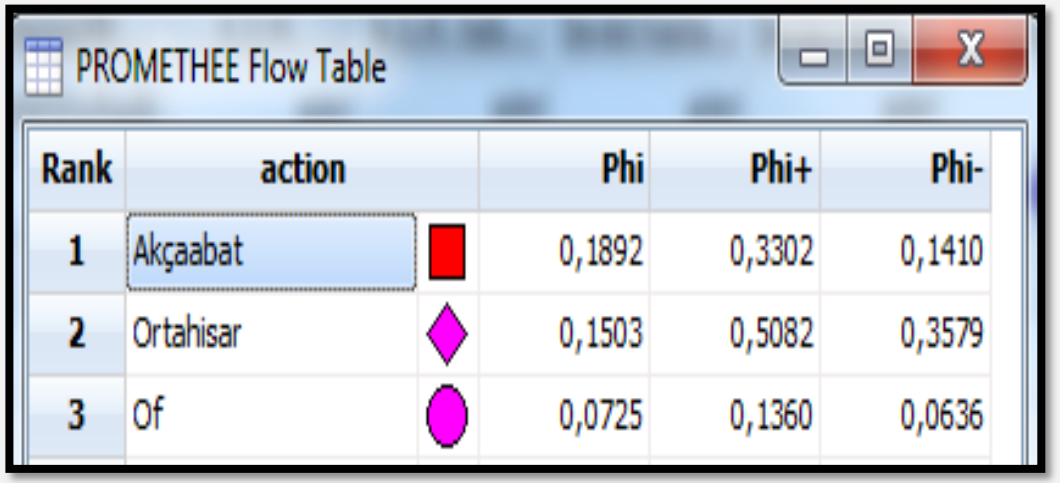


ANALYZING THE PROPLEM

PROMETHEE II RESULTS

PROMETHEE Flow Table

Rank	action	Phi	Phi+	Phi-
1	Akçaabat	0,1892	0,3302	0,1410
2	Ortahisar	0,1503	0,5082	0,3579
3	Of	0,0725	0,1360	0,0636
4	Araklı	0,0636	0,1393	0,0757
5	Beşikdüzü	0,0577	0,1137	0,0560
6	Çarşıbaşı	0,0518	0,1098	0,0580
7	Arsin	0,0473	0,1180	0,0707
8	Vakfikebir	0,0404	0,1152	0,0748
9	Hayrat	-0,0066	0,1228	0,1294
10	Sürmene	-0,0083	0,0886	0,0969
11	Yomra	-0,0250	0,1100	0,1350
12	Şalpazarı	-0,0353	0,0861	0,1214
13	Dernekpazarı	-0,0510	0,1012	0,1523
14	Maçka	-0,0791	0,0893	0,1683
15	Tonya	-0,0949	0,0564	0,1514
16	Köprübaşı	-0,1018	0,0643	0,1661
17	Düzköy	-0,1117	0,0532	0,1648
18	Çaykara	-0,1588	0,0401	0,1989



ANALYZING THE PROPLEM

- SENSITIVITY ANALYSIS

Criteria	Existing situation	Upper bound	Lover bound	Criteria	Existing situation	Upper bound	Lover bound
A1.Population	0.2891	0.35	0.11	B5.The number of branch hospitals in the county	0.0180	-	0.01
A2.Population density	0.17800	-	-	B6.Total number of beds in the county's branch hospitals	0.0135	-	-
A3.Centrality	0.0318	0.21	-	B7.The number of private hospitals in the county.	0.0095	0.12	-
B1.The number of FHC in the county	0.1198	0.25	-	C1.Distance to the main roads	0.1114	-	-
B2.The number of officials as physicians in the county's FHC	0.0496	19	-	C2Traffic congestion	0.0598	0.17	-
B3.The number of public hospitals in the county	0.0305	0.29	0.04	C3.Noise centers	0.0112	0.74	-
B4.Total number of beds in the county's public hospitals	0.0203	0.18	-	D1.Land cost	0.0572	0.77	0.04

CONCLUSION

- In this study, a hybrid MADM model is presented for suitable location selection at the level of counties for a hospital in Trabzon, Turkey. In the applied MADM model,
  - ANP is used to determine attributes importance,
  - PROMETHEE is used to prioritize location alternatives.
- As a result of the model, Akçaabat county is determined as the most preferred hospital location.
- The population of the county and the centrality of the location are the most important factors for Akçaabat to took first place.
- The knowledge about the intense working environment in Akçabat's only state hospital justifies this result.
- Also it is seen that first order in the ranking is not sensitive to the change in the attributes priorities.

CONCLUSION

Further Suggestions

- The number of participants in two groups may be increased.
- The patient's point of view can be included to model.
- The opinions of the residents of the city may be assessed.

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