GIS Supported Decision Approach for Housing Evaluation

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Key Words: Housing evaluation , AHP, WLC, GIS, Decision making

SUMMARY

Housing is one of the most important investments of people and states. Researches based on housing choice are generally based on studies on housing economics. In the choices of housing, both the individual choice and the spatial structure of the housing market should be considered together and physical characteristics, environmental characteristics, transportation mode and accessibility should be evaluated together. For this reason, housing choice is not a decision as randomly. Many different factors should be considered together.

The Analytical Hierarchical Process (AHP) method was first developed by Saaty and it is a multi-criteria decision making technique which is the well-known for decision support systems. In addition, spatial decision making support systems, which combination Geographic Information System (GIS),that designed based on location, and decision making techniques, are frequently used today. Weighted Linear Combination (WLC), which is one of the location based evaluation methods, is based on the weighted average concept that the criteria are standardized in a common numerical range. The total score of each alternative is derived from the sum of the weight values determined for the criteria and the score value products calculated within the scale for all criteria. Suitability values are calculated for all alternatives and the alternative with the highest suitability value is chosen as the best choice.

The 20 criteria that can affect the housing suitability value in the study were evaluated by the AHP method and weighed on the basis of the formulation of the method by creating binary comparison matrices. Using ArcGIS software, the location of 585 houses was marked as point-based on the Kayseri province satellite map. Then, the information of the 20 criteria of houses was entered in the attribute table. WLC score for 585 houses were calculated by means of WLC scale based each criteria. Raster maps were created for each criteria by using WLC method on the software and suitability values were obtained by entering weights.

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1. INTRODUCTION

Nowadays, with increasing the numbers of the people living in the cities, protection the environmental values, increasing the quality of the urban service and providing the quality of life have been become important. At this point, the concept of land usage and the development of urban areas which is suitable for this goal are one of the topics discussed in the urbanization literature (Tosun, 2013). Inland use planning, "creation of planned areas which include the types and usage of buildings and spaces to meet the different needs of daily lives of residents" has a critical importance (http://www.sustainablecitiesinstitute.org, 2017).

It is absolutely necessary to be known the value of the houses in order to get taxes by means of economical transactions such as renting, buying, selling, exchange, easement right establishment, in kind and limited rights registration in the land registry, partial or total expropriation, nationalization. Determination of the exact values of the houses and taxation will result in reduction of the demand for immovable property for the purpose of subjective and unearned income, and the real economy flow of the capital will be provided. Housing evaluation has a great importance in terms of many factors such as implementation of planned urbanization, selection of settlement areas, the comparison of internal and external connection costs, the economic evaluation of development plans, the consolidation of very small parcels in urban settlements, immovable property markets' clarification and securing, monitoring the price change on the market and so on.

In countries such as Turkey where housing is seen as a assurance, demand of housing as an investment from high income groups is important. In this case, there may be more than one housing in ownership, except for the house that is in use. The majority of these housing are offered in the market as rental housing stocks. For the middle and lower income groups, acquisition of housing is still an important problem. Especially the housing supply for the lower income group is a serious problem and policies which are for the housing acquisition of the lower income group are still insufficient. In this sense, the housing loan system is not yet able to function for its purpose. The main reason for this failure is that the interest rates on housing loans are still quite high in today's conditions (Alkan and Uğurlar, 2015)

In the high, middle and low income groups, it is often needed to evaluate the satisfaction of the housing area environment about the expectations of the users, needs, and their aims. Any assessment is the user satisfaction determinant when viewed from a large scale. Residential user satisfaction in the residential area reflects the answers of people to the neighbourhood they live in. Environment concept is not only related to the housing, the development of the housing area, the components of the physical residential area, which come from the

neighbourhood, but also the it is related to the social and economic (regulatory and institutional) situations. If the appropriate techniques are used in data collection and analysis, it is possible to measure the physical, social and regulatory factors that determine the degree of user satisfaction in the residential area. This information can not only be used to determine users' environmental responses, but can also be used to develop existing housing area features, design, and the qualities of new regulations (Francescato, 1998; Kellekci and Berkoz, 2006).

It has been seen that the decision making is defined as determination of the options that can give the most appropriate result by evaluating all aspects of the problems that should be finalized in case of an event or situation encountered at each management level. The Analytical Hierarchical Process (AHP) method was firstly developed by Saaty and is a multi-criteria decision making technique well known for decision support systems. In addition, spatial decision support systems, which combine Geographical Information Systems (GIS) and decision making methods based on location, are frequently used today. Spatial decision support systems are computer-based systems that facilitate decision-making on spatial problems, combining decision-making methods, optimization algorithms and data storage, synthesis and analysis of GIS in the solution of decision-making models. Weighted Linear Combination (WLC), which is one of the location based evaluation methods, is based on the weighted average concept that the criteria are standardized in a common numerical range. In this study, weights were determined by the AHP method. The convenience value of each alternative is derived from the sum of the weight values determined for the criteria and the score value products calculated within the scale for all criteria. The alternative with the highest convenience value is chosen as the best choice.

2. METHOD

2.1. AHP Method

The AHP method was firstly developed by Saaty (Saaty, 1980) and it is a multi-criteria decision making technique well known for decision support systems (Brent et al., 2007). This process is a flexible multi-criteria decision-making methodology that can solve a complex problem in a hierarchy according to one or more criteria (Mohajeri and Amin 2010). AHP is based on the ability of innate human beings to use knowledge and experience to predict relative sizes through paired comparisons. These comparisons are used to form ratio scales in various dimensions. Hierarchical or networked organization of the problem to be decided allows us to organize our basic logic and intuitions in a systematic fashion by dividing a problem into smaller constituent parts. For this reason, the AHP tries to achieve a hierarchical significance level value for weights and alternatives from simple binary comparative criteria (Bostancı et al., 2015). When verbal decisions are expressed according to preference level, an appropriate significance scale for binary comparisons emerges. These are: equally important =

1, slightly more important = 3, strong = strongly important = 5, very strong = significant = 7 = extremely important = 9. 2, 4, 6 and 8 can be taken as intermediate values (Saaty, 1980). The steps of the AHP method are given below.

Step 1: A binary comparison matrix is created by comparing benchmarks based on AHP importance ratings.

Step 2: Each component of the comparison matrix is divided by the sum of the columns and a standardized comparison matrix is calculated.

Step 3: The average of each line in the standardized comparison matrix is calculated. These mean values represent the weights of the criteria.

Step 4: The validity of the results of the AHP methodology depends on the consistency of the binary comparison matrix. Saaty uses the Consistency Rate (Consistency Rate - CR) is used. If $CR \leq 0.10$ than A binary comparison matrix is consistent. Otherwise, A binary comparison matrix is not consistent (Saaty, 1980; Saaty, 2006)

2.2 WLC Method

Weighted Linear Combination is based on the weighted average concept where criteria are standardized in a common numerical range. The decision maker assigns relatively weighted weights directly to a layer of feature maps. The total score of each alternative is derived from the sum of the weight values determined for the criteria and the score value products calculated within the scale for all criteria. Suitable values are calculated for all alternatives and the alternative with the highest eligibility value is chosen as the best choice. The method can be carried out using any GIS program with spatial analysis capabilities. These programs allow the layers created for each criteria to be brought together to determine the composite map by weighting. The method can be applied in both raster and vector GIS environments (Drobne and Lisec, 2009).

$$S_i = \sum Wi \,.Xi$$

Here:
S = suitable value
Wi = criteria weight
Xi = score value

The conversion of WLC score values for criteria containing numerical values can be calculated by the following formula (Malczewski, 2000):

$$Xi = \begin{cases} \dfrac{a_{ik}^{q} - \min\limits_{i,q}\{a_{ik}^{q}\}}{r_{k}^{q}}, & \text{for the } k-\text{th criteria to be maximized} \\ \dfrac{\max\limits_{i,q}\{a_{ik}^{q}\} - a_{ik}^{q}}{r_{k}^{q}}, & \text{for the } k-\text{th criteria to be minimized} \end{cases}$$

3. APPLICATION

In order to obtain the criterial weights in the study, 8 focus groups were established who were experts in housing valuation and the criteria were evaluated with AHP importance scale. By using the AHP method, a matrix of coefficients for 20 criteria was created and weights were obtained within the frame of the method steps (Table 1). Using the data on the houses, the WLC scale of each criterion and the WLC score values of 585 houses were determined on the Excel spreadsheet by the numerical and verbal conversion in Table 1.

Table 1. Determination of the score values and weights of the criteria used in the evaluation of the houses

Row No	Criteria Name	Determination Skore Value	AHP Weight
1	Housing Age	Numerical Conversion	0.0712
2	Housing front	North (0) ... South (1)	0.0908
3	Residential area	Numerical Conversion	0.0600
4	Number of rooms	1 Room (0) ... 5+ Rooms (1)	0.0415
5	Number of bathrooms	0 bathrooms (0) ... 3+ bathrooms (1)	0.0165
6	Landscape	Very poor (0) ... Very good (1)	0.0802
7	On-site status	No (0.50) ... yes (1)	0.0535
8	Condition of parking area	None (0) ... parking garage (1)	0.0362
9	Safety system status	Unsafe (0) ... Very safe (1)	0.0369
10	Building entry path width	Numerical Conversion	0.0362
11	Floors in housing	Numerical Conversion	0.0645
12	Distance to school	Numerical Conversion	0.0422
13	Quality of external structure	Numerical Conversion	0.0789
14	Type of heating	None (0) ...Central Heating (1)	0.0649

15	Fuel type	None (0) ... Natural gas (1)	0.0416
16	Dues Status	Numerical Conversion	0.0302
17	Rent income	Numerical Conversion	0.0649
18	Distance to city center	Numerical Conversion	0.0422
19	Distance to shopping center	Numerical Conversion	0.0284
20	Area Topographic structure	Mountainous (0) ... Flat (1)	0.0191

In the scope of study, Using ArcGIS software, the location of 585 housing of approximately 20 neighbourhoods was marked as spot-based on Kayseri satellite map (Figure 1)

Figure 1. Housing locations on satellite map

In order to apply location-based multi-criteria decision analysis in ArcGIS [2] software, a weight is applied to each of the specified criteria of the WLC score, and then the sum of the criteria's results is combined into a single layer to obtain a suitability map. In this case, 585 housing information with respect to the 20 criteria's has been entered in to attribute table. Point based raster maps were created for each criterion by using WLC method on the software and suitability values were obtained by entering weights (Si). In the method, values close to 1 indicate values appropriate for the decision maker and values close to 0 indicate inappropriate values.

In Table 2, the suitability values (Si) of the first 5 and last 5 dwelling units are given.

Table 2. Suitability values used in the evaluation of Housing

ID	Housing Name	Neighbourhoods	Si
2729	Forum Rezidans	Hunat	0.8441
2918	Forum Rezidans	Hunat	0.8440
3319	Bekaş konutları	Gültepe	0.8199
787	Sararpark	Köşk	0.4927
908	Sararpark	Köşk	0.4861
...	...	…	...
149	Boztoprak Apt.	Mimar Sinan	0.4248
216	Boztoprak Apt.	Mimar Sinan	0.4248
542	Arı Apt.	Ş.Nazımbey	0.3881
148	İpek Apt.	Mimar Sinan	0.3548
215	İpek Apt.	Mimar Sinan	0.3548

Suitability values obtained for each house can also be regarded as index values at the same time. Areal raster maps were generated using the IDW method using the suitability values (Figure 2).

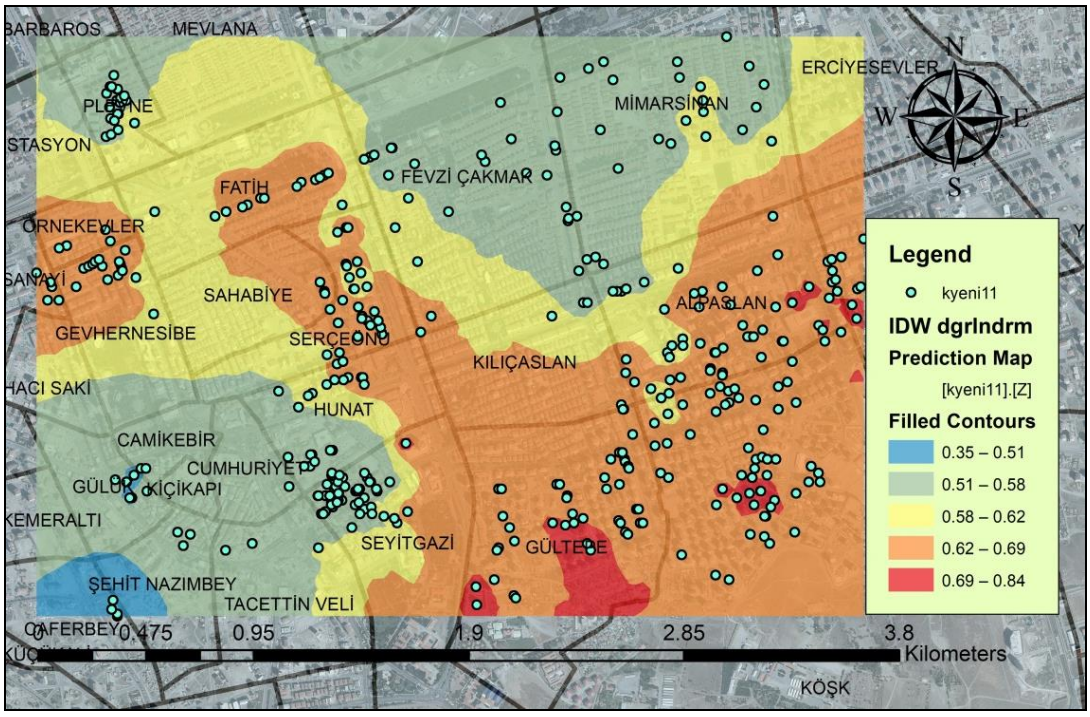

Figure 2. Housing evaluation map obtained by using IDW method

4. RESULTS AND SUGGESTIONS

In the method, weights were determined by AHP decision method. Among the 20 criteria determined, the most important criteria in weighting were the house front, the landscape and the quality of external structure. The GIS-based WLC method was used to evaluate the houses successfully with respect to the 20 criteria's.

Areal-based raster maps were generated by the IDW interpolation method using the suitability values obtained from the WLC method. According to the result of evaluation on the map, Köşk, Gültepe, Kılıçarslan and Alpaslan are the well suitable neighbourhoods. These neighbourhoods are the preferred neighbourhoods in terms of housing value and investment in Kayseri. The Suitability score map obtained with respect to the 20 criteria is similar to the housing value map.

Determined weights using different decision making methods such as Analytical Hierarchical Processes, Analytical Network Processes and TOPSIS can be used in WLC method. The weights determined by these methods are used in the WLC method and the results can be evaluated on the map and compared with the results obtained in the article.

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BIOGRAPHICAL NOTES

Bülent Bostancı was born in Aksehir, Turkey, in 1969. He graduated from Yıldız Technical University, Istanbul, Turkey in 1992, and received MSc and PhD degrees from Yıldız Technical University, Istanbul, Turkey in 1995 and 2008. He worked at Republic of Turkey General Directorate of Highways for 5 years. He received his Assistant Professor degree in Turkey in 2010. He is now working for Erciyes University, Kayseri, Turkey as the Head of the Surveying Technical Division at the Department of Geomatics Engineering. His research interests are special engineering surveying, real estate development and risk analysis.

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