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Use of Spatial Analysis Methods in Land Appraisal; Konya Example

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Abstract:

Real estate valuation is an important topic needed to be studied carefully because of that there are a lot of subjective criteria individualized. The type of real estate in the study was considered as land, the value indices were created with the help of Geographic Information Systems (GIS) using Neighborhood and Locational factors for Konya/Turkey province. While the indexes were being created, the results of the frequency analysis of the questionnaire study on the criterion affecting the value were utilized.
The value of land that is subject of purchase-sale in the settlement districts of Konya province is collected from the market. Legal and physical characteristics of the know value of land have been added to local and spatial indexes. The appraisal of the land were estimated by Multiple Regression Analysis (MRA) method. In the study results determine the model performance were calculated comparatively and results were analyzed by integrating GIS.

Key words: Mass appraisal, real estate valuation, GIS, regression.

1.Introduction

Real estate valuation is valuation estimation considering by plot, land, residence, commercial, etc. of real estate's legal, physical, spatial and neighborhood characteristics within a certain period of time of real estates. Taxation, insurance, expropriation (confiscation) and other important transactions that an important contribution to the economy of the country is an important issue. Modern valuation methods should be used due to traditional valuation methods are left in mass appraisal applications. For the methods that can be used in mass real estate valuation, the optimum time of the criteria that affect the value is important in terms of labor and cost. In this study, plot was considered as the real estate type and the criteria affecting the land value were examined. In urban areas, such as residence, commercial, institutions etc. which is the basis of fields of importance, especially due to reasons such as migration, urban projects, are increasing day by day. The construction of appropriate projects without speculation and unearned income are directly related to the determination of value in transparently. This way is to obtain the criteria that affect the optimum standardized plot value.

In the literature studies, special criteria have been searched in general for the effects and associations on residence real estate values. For instance, the green zones in the neighborhood [1], Brownfield settlement [2], campus areas [3], number and distance of public transport stops [4], boreholes [5], zebra mussel [6], proximity to access infrastructure and accessibility [7], natural risks such as floods, avalanche [8], state forests [9], Pennypack Park [10], traffic noise pollution [11-12], air pollution [13-14], natural landscapes such as sea, mountain, street and building [15], pleasant and unpleasant landscapes [16] and the effects of shale gas [17-18] have

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been investigated on the real estate value. Public transport [19] and urban architecture [20] have been associated with the real estate value also. It is understood that almost all of these studies addressed specific criteria related with location.

There are studies in which addressed on its own location-based criteria. Techniques for location modeling have been identified by demonstrating an analytical approach based on the development of location properties [21]. Spatial properties were analyzed by hedonic method using location weight matrix to reveal spatial correlation [22]. Foliage, surface water, noise effects and landscape fetures from consisting of environmental factors in association with real estate value was investigated by correlation analysis [23]. The relationship between residence values and determinants of both the urban environment and the structural characteristics of the residence market has been analyzed [24].

Studies with regard to investigation of real estate valuation methods and the development of the real estate valuation system have been carried out. Pagourtzi et al. [25] in their study, it has been examined individually by classifying the valuation methods and it has been found that there is a difference in the criteria, the criterion numbers and the groupings for each method. Using the GIS technology [26], an real estate valuation system was developed according to YSA and hedonic models [27]. Moreover, the tax value of land type of real estate has been estimated by using sales comparison, multi-attribute market value assessment (MAMVA) and mass appraisal methods for real estate taxation system [28]. The purpose of this study is to generate an index with the help of GIS for the spatial and neighborhood features of the criteria affecting the plot value and is to verify by using MRA. The indexes were created by the weights obtained from the frequency analysis results of the previous survey study. Each classified to raster maps weighted summation of the criteria of weights and spatial properties was applied. In Konya city center at settlement of neighborhoods, which are subject to purchase and sale of plots that markets and corresponding index values were added to the data set. The values of the market samples, legal and physical characteristics are also added to the data set. The data set was edited and value estimates were made by multiple regression analysis (MRA) method. Performance analysis were applied to compare market value with model value.

2. Materials and Method

As the market sampling area, central neighborhoods close to Konya/Turkey city center were preferred. As you move away from the city center, you are encountering the neighborhoods of the central districts, which were formerly called villages. Therefore, the density of the plot will decrease in remote neighborhoods. Because of using data of plots with the optimum criteria during the model verification phase, the neighborhoods in the central districts of Karatay, Meram and Selçuklu of Konya were taken as study areas. Maps of the study area were provided and necessary arrangement were made (Figure 1).

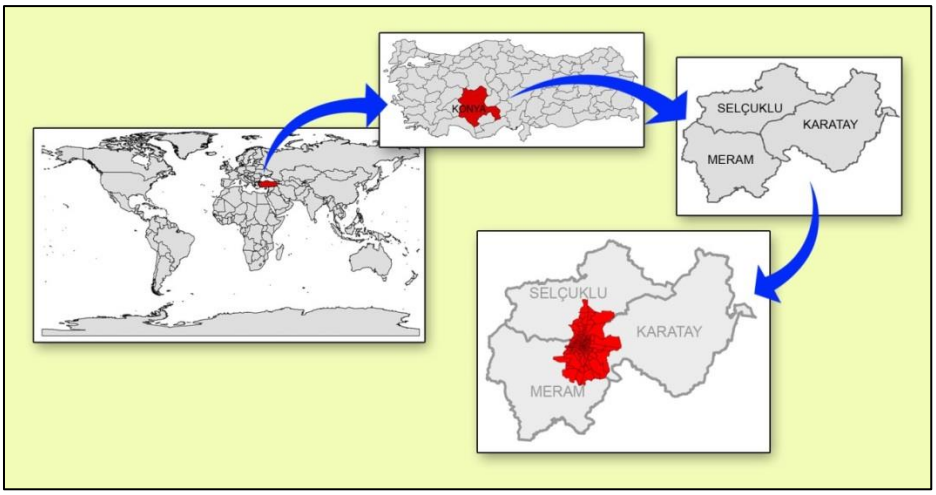

Figure 1. The area of market sample

2.1. Criteria Affecting Plot Value

There are many criteria that affect the plot value, both objective and subjective. These criteria are grouped into major topics as legal, physical, spatial and neighborhood features (Table 1).

The data related to the criteria for neighborhood features were collected on a small scale based on a neighborhood-based and others on a large scale parcel-based. Moreover, market samples were obtained by providing the values of the plots which are subject to purchase–sell in central neighborhoods. Most of the criteria corresponding to the market samples have been reached. Unreachable data could not be included in the model by ignoring.

2.2. Multiple Regression Analysis

In multivariate regression analysis, the independent variables are trying to explain the change in the dependent variable simultaneously. The model of the MRA analysis,

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} + u_i \quad (1)$$

y_i : Dependent variable (value of real estate)
$x_{i1}, x_{i2}, \ldots x_{ik}$: Independent variables (share, area, TAKS, KAKS, number of floors, etc.)
u_i : Corruption or error term.
β_0 : Constant
$\beta_1, \beta_2, \ldots \beta_k$: coefficients of variation

can be demonstrate by a general formula . The F test in the result of analysis and R^2 are the important concepts to be checked first. The F test is a test with ANOVA to examine whether the regression model is significant. The level of significance corresponding to the value of F resulting from the ANOVA test helps in determining whether the created model is appropriate. The result of F test is significant ($p < 0.05$), it is interpreted that the model contributes significantly to explain the dependent variable. The R^2 value indicates that how many percentage

of the variance in the dependent variable is explained by the independent variable [29]. The closer this value is to 1, the better the model is explained by the independent variables [30].

Table 1. The criteria affecting value of the land (are subheadings, written in bold and italic).

NO	**A. LEGAL FEATURES**	**Q38**	**Proximity to Educational Institutions**	Q78	Proximity to underpass/ overpass
Q1	**Property Conditions**	Q39	Proximity to Pre-schools	**Q79**	**Proximity to Unsanitary Areas**
Q2	Full Ownership	Q40	Proximity to High Schools	Q80	Proximity to was disposal areas
Q3	Shared Ownership	Q41	Proximity to Higher Education Institutions	Q81	Proximity to treatment facilities
Q4	**Zoning Status**	Q42	Proximity to courses	Q82	Proximity to natural gas and tube filling facilities
Q5	The Gross Floor Area	**Q43**	**Proximity to Public Institutions**	Q83	Proximity to petrol stations
Q6	Total Construction Area	Q44	Proximity to governorships	Q84	Proximity to base stations
Q7	The number of floors≥10	Q45	Proximity to Municipalities	Q85	Proximity to energy transmission lines
Q8	The number of floors<10	Q46	Proximity to Courthouse	Q86	Proximity to underdeveloped areas
Q9	Detached Building	Q47	Proximity to Jailhouse	Q87	Proximity to marsh areas
Q10	Attached Buildings	**Q48**	**Proximity to Security Units**	Q88	Proximity to natural disaster areas
Q11	**Legal Restraints**	Q49	Proximity to Police Stations	Q89	Proximity to not improved river areas
Q12	Right of Mortgage	Q50	Proximity to Military Zones	**Q90**	**Proximity to Industrial Zones**
Q13	Easement	Q51	Proximity to Fire Departments/ 112 Emergency	**Q91**	**Proximity to Graveyards**
Q14	Annotation of Lease	**Q52**	**Proximity to Attraction Centers**	**Q92**	**Proximity to Worship Places**
Q15	***Plot Area***	**Q53**	**Proximity to Shopping Centers**	**Q93**	**Proximity to Business Centers**
NO	**B. PHYSICAL FEATURES**	Q54	Proximity to Hypermarkets	**Q94**	**Proximity to Parking Areas**
Q16	***The location of the plot***	Q55	Proximity to mini-markets	**Q95**	**The View From The Plot**
Q17	Corner parcel	Q56	Proximity to open/closed bazaars	Q96	Mountain, valley, etc. views
Q18	Intermediate parcel	Q57	Proximity to commercial enterprises	Q97	Lake, river, stream, etc. view
Q19	**Geometric Structure**	**Q58**	**Proximity to Cultural Centers**	Q98	City view
Q20	Length of the Frontage	Q59	Proximity to cinemas/theaters	**NO**	**D. NEIGHBOURHOOD FEATURES**
Q21	The number of frontage	Q60	Proximity to historical sites and touristic attractions	**Q99**	Population density
Q22	Geometric shape	**Q61**	**Proximity to Entertainment Centers**	Q100	Education Level
Q23	**Technical Infrastructure Services**	Q62	Proximity to fairs, concert areas, etc.	Q101	Level of income
Q24	Water supply	Q63	Proximity to sport facilities	Q102	Immigrant receiving
Q25	Electricity, sewer, natural gas, and telephone	Q64	Proximity to stadium/hippodrome	Q103	Criminal Rate
Q26	Solid waste collection service	Q65	Proximity to entertainment venues	Q104	Neighborliness Relations
Q27	Storm drainage	**Q66**	**Proximity to Green Areas**	Q105	Homeowner/tenant
Q28	Unpaved road	Q67	Proximity to forest/copses	**Q106**	**The Surrounding Environment**
Q29	Asphalt road	Q68	Proximity to recreation areas	Q107	The favorite neighborhood
Q30	**The Road Condition**	Q69	Proximity to parks	Q108	Residential Density
Q31	The Periphery Road	Q70	Proximity to playgrounds	Q109	Development potential
Q32	Road width≥10	**Q71**	**Proximity to Public Transportation Points**	Q110	Purchasing and selling mobility of real estate
Q33	Road width<10 metre	Q72	Proximity to airports	**Q111**	**Underground, soil, and aboveground features**
Q34	**The Slope of The Plot**	Q73	Proximity to railway stations	Q112	Slope of the neighborhood
NO	**C. LOCATIONAL FEATURES**	Q74	Proximity to coach station	Q113	Geological condition
Q35	**Proximity to Health Facilities**	Q75	Proximity to tramway, subway and metrobus stations	Q114	Climate Condition
Q36	Proximity to health center, dispensary, etc.	Q76	Proximity to bus stops	Q115	Air Pollution
Q37	Proximity to State/Private Hospitals	Q77	Proximity to shared taxi routes	Q116	Noise Pollution

2.3. Performance Analysis

The results of the mean absolute error (MAPE) (2), the root mean square error (RMSE) (3) and the mean absolute error (MAE) (4) were used in the performance analyzes to compare the model values and the market values obtained from the criteria. The performance of the model is investigated with these error rates especially in the studies in which the method is developed for real estate valuation [31-36].

$$MAPE = \frac{1}{n}\sum_{i=1}^{n} \frac{|y_i - \hat{y}_i|}{y_i} \quad (2)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (y_i - \hat{y}_i)^2} \quad (3)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n} |y_i - \hat{y}_i| \quad (4)$$

$y_i = Market\ values,$
$\hat{y}_i = Model\ values,$
$\bar{y} = Average\ market\ values,$
$i = 1, 2, 3, \ldots . n$
$n = Number\ of\ selected\ samples$

3. Result and Discussion

3.1. Index Generation

The subtopics and location index of the spatial properties are obtained. There are a total of 12 of these are Health (Q36-37), Education (Q39-42), Government Agency (Q44-47), Security (Q49-51), City Center (Q52), Shopping (Q54-57), Culture (Q59-60), Entertainment (Q62-65), Green Zones (Q67-70), Transportation (Q72-78), Harmful Areas (Q80-89) and Others.

The proximity analysis was applied considering the criteria for each subtopic that is, the accessible distances of the outfits available in the map, and raster maps were attained by classifying them in the range 1-5. Using the weights of the frequency analysis in the previous survey study, the maps were combined and indexes were produced. For instance, in order to obtain the health index map, equipment with the heading "health center, dispensary, etc." have been applied proximity analysis at distances of 250-500-750-1,000-1,250 meters on the map (Figure 2a). Since this analysis is in the resultant vector format, it has been converted to raster form (Figure 2b) and the closest distance to the 0-250 m range is 5 points, the distance from the 1,250 meters is 0 points and is classified in the range of 0-5 (Figure 2c). The same processes were applied to the outfits also in the "state/private hospitals" layer (Figure 2d). Thus, there are two criteria under health institutions, namely "health center, dispensary, etc." and "state/private hospitals" and classified raster maps are obtained. The map consisting of the pixel values of the maps multiplied by weights of 3.91 and 3.87 respectively in the survey has been produced the Health Index Map by reclassifying between 1-10, (Figure 2e). Similar processes were applied to Education, Government Agency, Security, City Center, Shopping, Culture, Entertainment, Green Zones, Transportation, Hazardous Areas and Others also by considering the grouping in the survey and their indexes were generated and the location features of the subtopics were obtained.

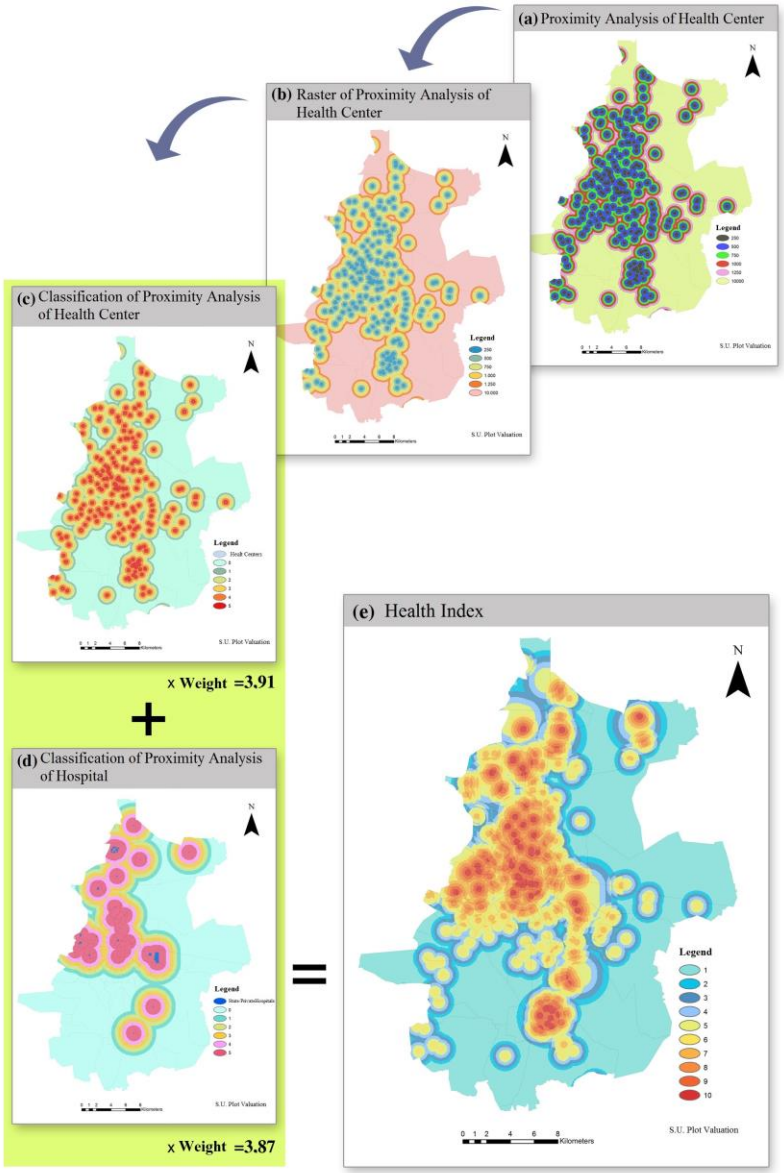

Figure 2. Production of health index map from location features

The pixel values corresponding to the market samples are transferred from ArcGIS to the data set in matrix form according to the criterion analysis methods. If the market samples correspond to two or more pixel values, weighted averages are calculated by taking the fields of the samples into account and added to the data set.

3.2. Model Verification

MRA was applied to the data of legal, physical, neighborhood features and location index of market samples in the center neighborhoods of Konya using SPSS software. As a result of the analysis, since the significance level (0.000) p <.05, corresponding to the F values in the ANOVA test, indicates that the regression analysis is appropriate and the models are significant. The criteria that make up the model account for about 85% of the market value and 15% cannot be explained for reasons such as economic, non-existent data and unearned income.

Model values were calculated using the coefficients of the criteria in consequence of. The data distribution of the market value and the model value is examined and the line equation of the trendline is obtained with R^2. It has been understood that the R^2 value is with 0.85 is close to 1 and the criteria described the model well. Moreover, the fact that the x coefficient of the line equation is close to 1 shows that the model value approaches the market value (Figure 3).

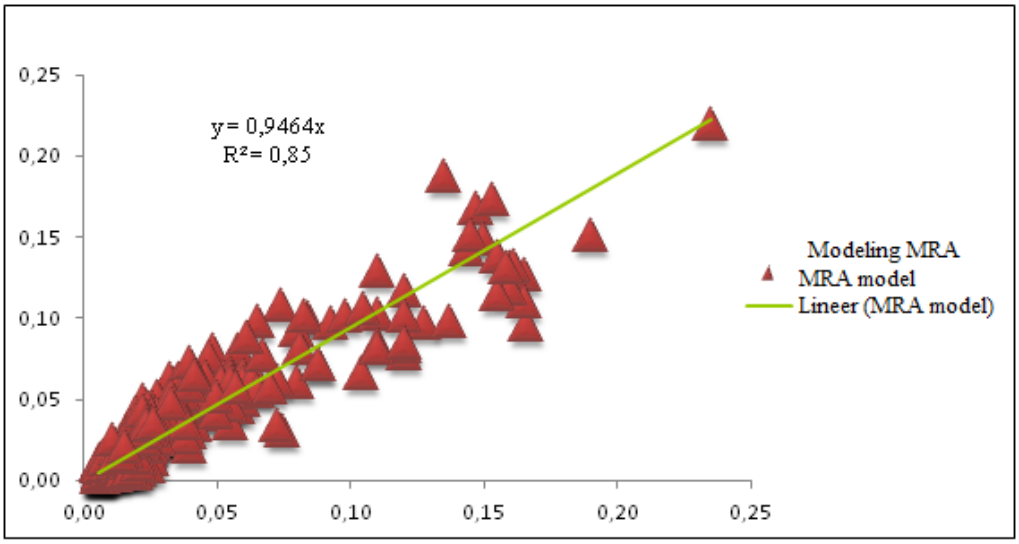

Figure 3. Data distribution of model

3.3. Performance Analysis

MAPE, RMSE, and MAE ratios of the value obtained from the model with market value by calculating the performance of the model was examined. The MAPE ratio of the model is 0.287, which is close to about 29% of the market value. It is also seen that the model has good performance in the form of RMSE 0.013 and MAE 0.008. The model value of market samples $\mp$0.032 shows the distribution of standard deviation between samples.

Table 2. Performance results

	Number of criteria	Standard deviation	R^2	y=ax	MAPE	RMSE	MAE
Model	41	0.032	0.850	y=0.9464x	0.287	0.013	0.008

4. Conclusion

Criteria affecting real estate value vary from country to country, from region to region and from person to person and there are many criteria. Criteria for mass appraisal studies should be determined at optimum level. In this study, the indexing process was carried out by grouping the criteria that affect the value of the plot. It has been reduced to 12 by indexing with a total of 64 criteria including subtopics and criteria of spatial properties. Real estate valuation is linked to GIS and GIS is a good means that can be used in almost every stage of valuation. So as to regulate the data of neighborhood and spatial features and to generate location indexes benefited from GIS. GIS is used to standardize data and generate value maps also. Criteria for determination, which is going to be base to mass real estate valuation is very important in terms of reaching fast, accurate and quality valuation results as they make up the basis of the subject. Criteria, which are going to reflect the basic characteristics of real estates in a region should be handled with great care. Because the union of these criteria will bring about for the economic corresponding of each real estate. Geographical data models were produced with indices for use in mass appraisal methods and criteria were standardized. Moreover, the spatial features are reduced in the criterion numbers and at the optimum level criteria have been obtained. The model, which is produced from legal, physical and neighborhood features and location indices, is explained by 85% with 29% error rate. In other words, the model obtained with 41 criteria that it is seems to explained 85% of the plot value, which is the dependent variable. The part of unexplained 15% of the model has been determined to be due to variable economics, rent, political conditions and non-existent data.

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