HEDONIC MODELING OF HOUSING PURCHASE/SALE DENSITY WITH URBAN CHANGE FACTORS

Halil Emre PIRBUDAK[1], Şükran YALPIR[1]*, Ali Utku AKAR[1]

[1]Konya Technical University, Department of Geomatics, Konya, Turkey
halilemrepirbudak@hotmail.com; syalpir@ktun.edu.tr; auakar@ktun.edu.tr

KEY WORDS: Housing Purchase/Sale Density, Geographic Information Systems, Hedonic Method, Real Estate Value Modelling, Urban Change Factors.

ABSTRACT:

Due to the industrialization in the cities, land needs have appeared in the increasing urban population. These needs have created houses with the accumulate of collective living spaces in the city. It is necessary to determine the supply-demand relationship and value of these real estates with economic importance for smart urban management systems and decision support systems in the market. The value of real estate varies according to the country in which it is located, but in general, it is affected by many factors such as spatial attributes, demographic factors, building factors, economic conditions. Depending on these factors, values and purchase-sale densities of housing also change.
In this study, for prediction of housing purchase-sale density, hedonic modeling was realized with 15 features from urban change factors. Urban change factors that affect the purchase/sale of housing such as land use, demographic factors, population density and structural factors have been examined through Geographic Information System (GIS). The hedonic regression method was used for predicting the density of housing purchase/sale. As a result of the modeling, it was found as $R^2 = 0,85$.

1. INTRODUCTION

The concept of the land, which forms the basis of the land, is the physical material that forms the outer surface of the world that makes life possible. For this reason, the land covers the vegetation, especially the soil, underground, surface waters and mines the concept of land forms the basis of the concept of real estate right. Therefore, the features depending on the location are important in the valuation of real estate. Besides, there are more features based on location than other legal, physical, and structural features (Yalpır and Unel, 2016).
In the mass valuation of real estates, comparison, income and cost methods are not sufficient (Pagourtzi et al., 2003; Erdem, 2017). In valuation activities for tax purposes which are important for the economies of smart cities, attributes of real estate in a certain region, database and features that affect the value should be used together. Therefore, which are modern and statistical methods in mass real estate valuation, Artificial Neural Networks, Spatial Analysis, Fuzzy Logic and Multiple Criteria Decision Analysis are used in value prediction.
As well as the values of real estate, purchase/sale densities are also important in terms of both their effect on the value and examination of factors that affect the purchase and sale. Purchase/sale densities known as regional change are affected by the spatial, structural and demographic changes occurring in the region. It will be important for decision-makers to know which of these variables will stimulate region trading when future intervention is made. Also, real estate taxes constitute a large part of the local government's income source. With this work, it will be possible to use the model formed as a base for real estate tax for smart cities.
The aim of the study is to create a mathematical model by using the spatial, structural, demographic changes and purchase-sale densities, which are among the factors of urban change in 2012 and 2018. In the study covering the central neighborhoods in Konya's Selçuklu district, in Turkey, the data set was created with the 15 factors in the specified groups for the years 2012 and 2018. Hedonic modeling was implemented by analyzing the correlation between the data.

2. MATERIALS AND METHODS

2.1. Real Estate Value

Real estate valuation, it can be defined as determining of real estate value by evaluating objectively the factors such as quality, benefit, environment, usage conditions of a property. This value can be a cost price. There may also be market and sales prices and are found using various methods. In addition to the large number of factors that affect value in general terms, there are four main factors: utility, scarcity, limitation and purchasing qualification. The principle of supply and demand in the economy reflects a complex relationship of these four value factors. If the demand for real estate increases, so does its value.
In our country, real estate valuation is made for direct or indirect use in many ways. These studies are not only for estimating the market value but also in the form of tax collection, expropriation, zoning, urban transformation practices, land-land arrangements, management of real estate, municipal revenues, insurance, inheritance, establishing rights on real estate, in some cases determining the sales prices or rents of real estate is used (Yomralıoglu et al., 2011). In these studies, there is a constant need for an objective appraisal of real estate values. For this reason, it is important for both ensuring the transparency of real estate markets and fair realization of public and private sector valuation practices. It is important for countries to establish well-functioning valuation systems and to revise their systems according to the needs that may arise in the future in decision support systems .
The determination of real estate value and reflection of these values to the tax is the main economic of communities (Ozkan and Yalpir, 2005). Mass valuation is important in terms of taxation, creating price indices and analyzing market dynamics (Jahanshiri et al., 2011). Developing computer technology and

information systems have made significant contributions to the real estate valuation field. Especially, spatial statistical analysis can be done more easily today. By integrating these statistical/verbal data with Geographical Information Systems, it has become possible to produce real estate value maps (Yomralıoglu et al., 2011).

2.2. Hedonic Method

The hedonic price method takes into account that the value depends on the services that can be obtained from the qualitative and quantitative characteristics that make up it. This is formed by evaluating the contribution of influencing factors on the price of a property (Rosen, 1974). Therefore, according to the hedonic price method, the value of property can be expressed as the sum of the contributions of its values. The purpose of the hedonic model is to estimate the price of real estate as a function of its real estate (Noor et al., 2015). In theory, the price paid for the purchase of real estate can be parsed into the hedonic prices (implicit prices) of individual attributes that make up the entire unit. The resulting regression coefficients provide the real property values and contribution to obtain the final property value.
The main application areas where the hedonic method is mostly used is related to the evaluation of negative environmental externalities in urban areas and subsequently with urban planning policies (Corielli et al., 1996; Sheppard, 1997). It has also been preferred in analyzing the change in real estate value through the land rent change (Bowes, 2001; Fletcher et al., 2000). With the hedonic method (Brander and Koetse, 2011; Czembrowski and Kronenberg, 2016), the effects of social, environmental and urban factors on real estate values have determined (Andersson et al., 2010; Netusil et al., 2014). It has also possible to highlight the importance of proximity to public services and to determine the impact of environmental factors such as parks (Lutzenhiser and Netusil, 2001; Limsombunc et al., 2004). It is always necessary to collect a large amount of data to obtain a working sample that represents a sufficiently broad case and to reliably analyze the weight of each factor on selling value (Locurcio et al., 2020).

3. APPLICATION

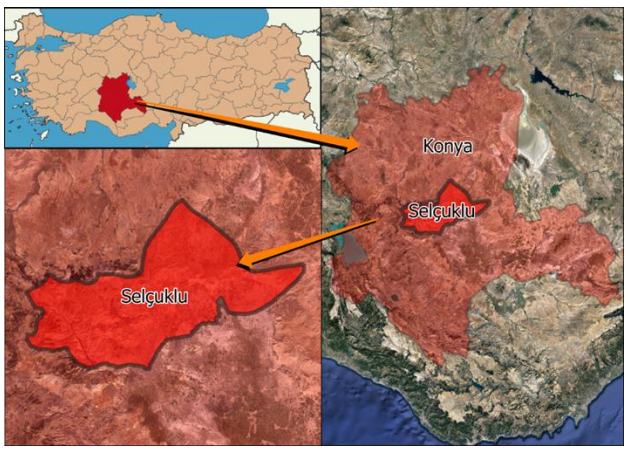

Figure 1. The study area

The central neighborhoods of Selçuklu/Konya district were included in the study (Figure 1). In the district, where new buildings are concentrated, the rate of purchase and sale is higher than in other central districts. Konya, Turkey's largest province in terms of surface area and is the seventh most populous city (Konya, 2021). In the study, macroeconomic factors were evaluated in order to determine the purchase/sale density and neighborhood boundaries were used (Table 1).
From the macro factors in Table 1, the number of purchases and sales by neighborhood was taken as the result variable. Hedonic regression analysis was used to understand the effect of these 15 factors on purchases and sales density. The data obtained in the study and their sources are shown in Table 2. In Selçuklu/Konya selected 25 central neighborhoods were investigated in this study (Figure 2).

Demographic Data (Population Education Status)	Land Use Data	Structural Change Data	Output Data
1-Non-literate	1-Urban areas	1-Housing area	Purchase/sale density
2-Primary-secondary-high school graduate	2-Industrial and commercial areas	2-Housing construction area	
3-Graduated from a university	3-Green urban areas and sports areas	3-Convention centers	
4-Master's and PhD graduate	4-Permanent crops areas		
5-Population	5-Pastures and herbaceous vegetation associations		
	6-The area of neighborhoods		
	7-Others (mineral extraction and dump sites, land without current use etc.) areas		

Table 1. Preferred macro factors in the study

Factors	Data Sources
Land use	CORINE 2012 ve 2018
Population	Turkish Statistical Institute in Turkey
Education Status	Turkish Statistical Institute in Turkey
Structural change	Turkish Statistical Institute in Turkey
Purchase- sale density	General Directorate of Land Registry and Cadastre Parcel Inquiry Administration

Table 2. Used macro data and data sources

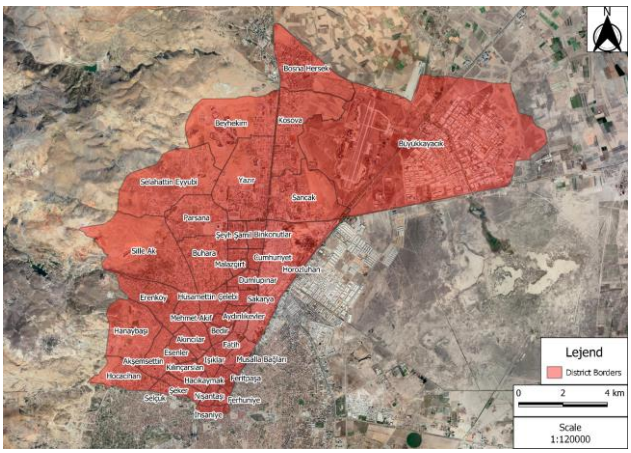

Figure 2. The central neighborhoods of the Selcuklu District, Konya, Turkey

In the first stage, Urban Atlas data of 2012 and 2018 were arranged in QGIS 3.16.2 software to create a land-use map (Figure 3 and Figure 4). The land qualities of the selected neighborhoods by years and the area they cover at the boundaries of the neighborhoods for each quality were calculated. In addition, the land use change by years is given in Table 3.

	2012	2018	Change
Urban Areas	20.527505	23.595458	3.067953
Industrial And Commercial Areas	18.733224	24.321577	5.588353
Green Urban Areas	1.812013	2.754191	0.942178
Permanent Crops Areas	7.288375	6.194215	-1.09416
Pastures Areas	37.106192	28.196465	-8.909727
Others Areas	70.476886	70.882296	0.40541

Table 3. Area changes in land classes according to Urban Atlas data

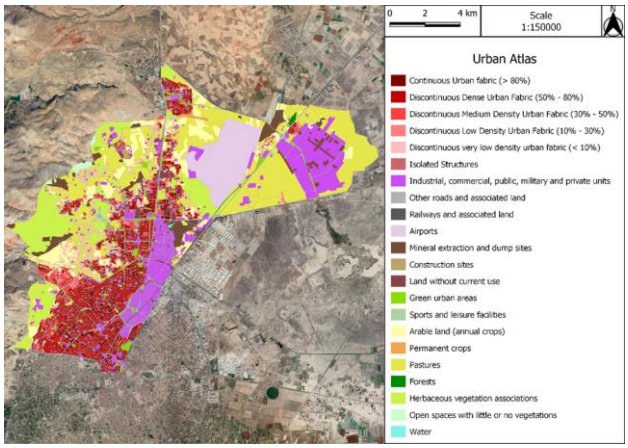

Figure 3. Land use Urban Atlas Map 2012

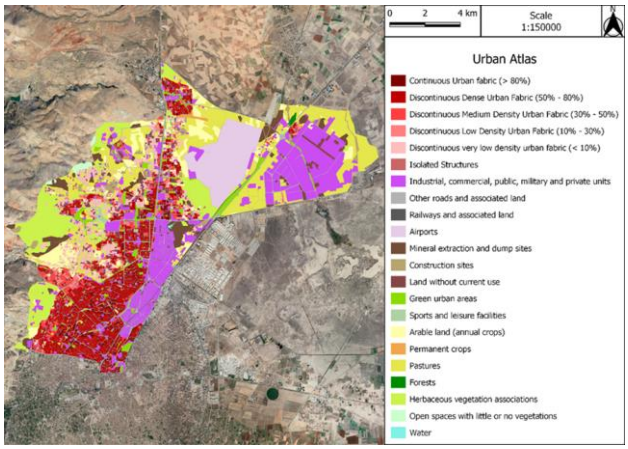

Figure 4. Land use Urban Atlas Map 2018

The spatial distributions of demographic and structural variables in the study area are given in Figure 5, Figure 6, Figure 7 and Figure 8. Between 2012 and 2018, there were changes in the boundaries and numbers of the neighborhoods. Thus, the neighborhoods where changes, in order to ensure the standard among the data, were removed from the study data set, and the hedonic analysis was realized over 25 neighborhoods in total.

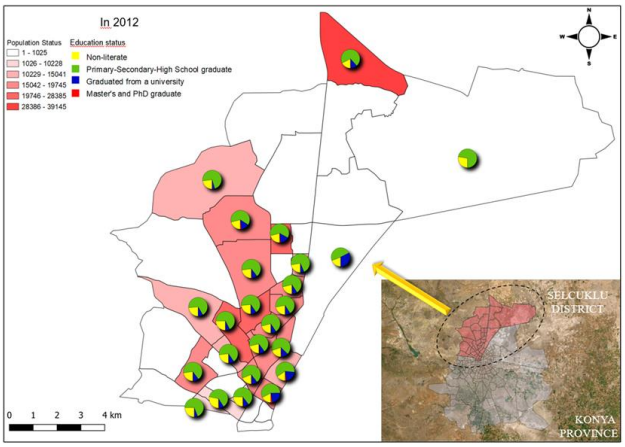

Figure 5. Spatial distribution of demographic data for 2012

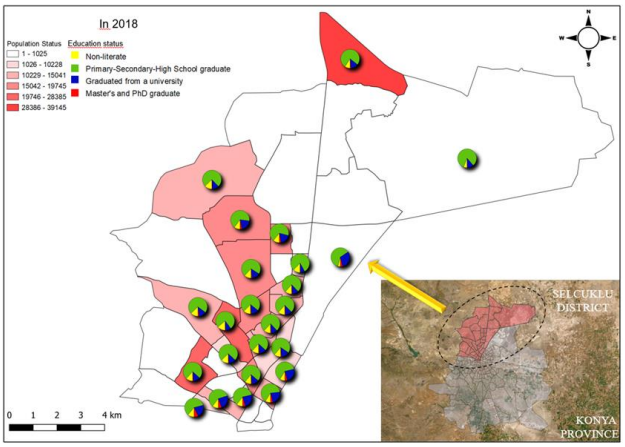

Figure 6. Spatial distribution of demographic data for 2018

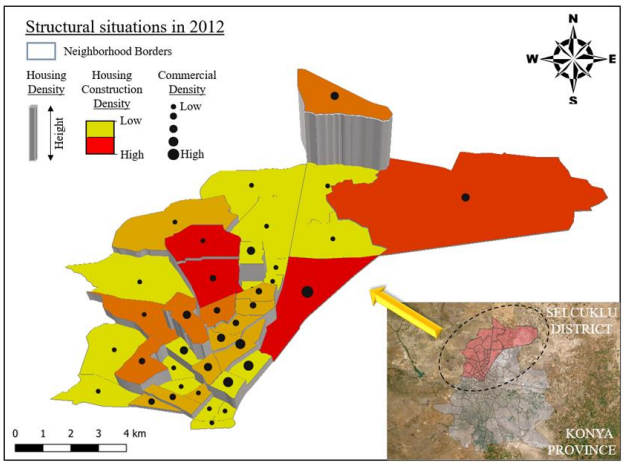

Figure 7. Spatial distribution of Structural data for 2012

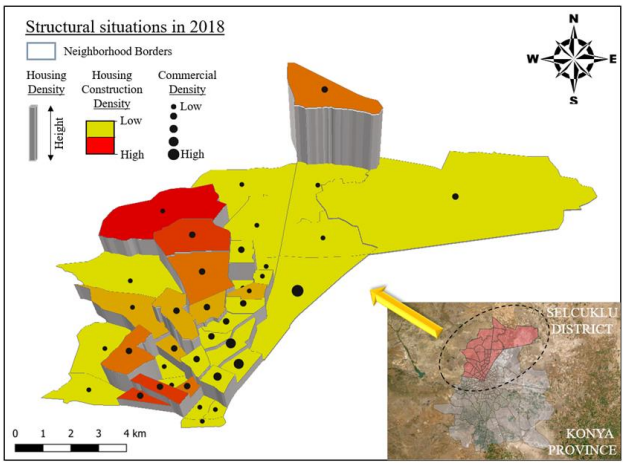

Figure 8. Spatial distribution of Structural data for 2018

The purchase-sale density map of 2012 and 2018, obtained from the parcel inquiry application of The General Directorate of Land Registry and Cadastre, are given in Figure 9 and Figure 10.

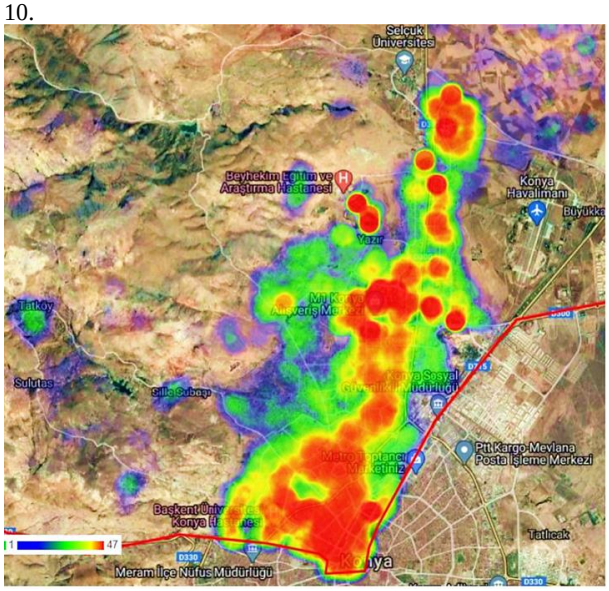

Figure 9. Purchase/sales density map for 2012

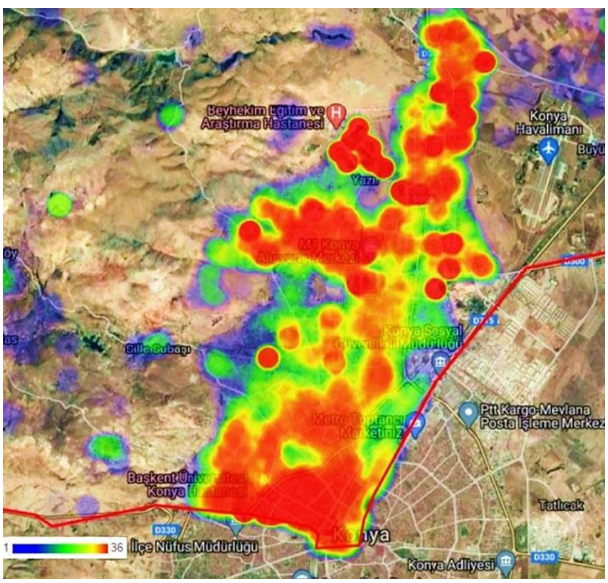

Figure 10. Purchase/sales density map for 2018

4. RESULTS

Multiple linear regression was used mathematical model for estimating purchase-sale density, paying attention to correlation relations. According to the comparative analysis of the data above, linearity was observed in the data of the neighborhoods. It was decided that this linearity can be modeled by applying multiple linear regression. Three different models were created in the study (Table 4). Three different regressions were applied, due to the high correlation between pasture, neighborhood area and population data.

Feature	R-1	R-2	R-3
Constant variable	-0.530	-0.180	-0.490
Urban areas	0.138	0.061	0.130
Industrial and commercial a.	0.153	-0.120	0.152
Green urban and sport a.	0.033	0.020	0.030
Permanent crops a.	0.720	0.562	0.703
Pastures and herbaceous veg.	-	-0.535	-
The area of neighborhoods	-0.717	-	-0.697
Others	0.105	0.084	0.104
Population	-0.833	-0.833	-
Non-literate	0.461	0.461	0.334
Pri-sec-high school	0.266	0.266	-0.321
Graduated from a university	0.265	0.265	0.185
Master's and PhD graduate	-0.180	-0.180	-0.195
Housing area	0.368	0.368	0.304
Housing construction area	0.767	0.767	0.761
Commercial area	0.017	0.017	0.021

Table 4. Multiple linear regression models and variable coefficients

It was observed that the coefficients of demographic and structural data did not change in the coefficients in the R-1 and R-2 models. However, the coefficients varied in the land use data. Especially with the removal of the area of the neighborhood, industrial and commercial coefficient became negative and the effect of the city structure decreased. In the permanent crops areas, which is one of the factor with the highest coefficient in the R-1 model, the coefficient of the R-2 model also decreased.

Among the land use criteria considered for the R-1 and R-2 methods, the factor with the highest weight of permanent crop areas (0.720) was found. For R-1 model, the area of neighborhoods is effective in real estate buying and selling, but it is negatively (-0.717) related. In the demographic data, the effect of the population was observed in the opposite direction with the highest weight. In structural change factors, the increase in construction areas was found to be more effective than other structural factors.

When we look at the R values calculated as a result of the analysis of all three applied models, it is observed that each of them is close to 1. R-1 and R-2 application results were the same. In the R-3 application, the success in modeling decreased slightly with the value of 0,873 R^2, which was found without using population and area variables (Table 5).

Model	R	R^2	Adjusted R^2	Std. Error
R-1	0,935	0,875	0,825	0,07718
R-2	0,935	0,875	0,825	0,07718
R-3	0,934	0,873	0,827	0,07653

Table 5. Analysis results of regression models

5. CONCLUSION

This study, it is aimed to create a model to estimate the purchase-sale density. Therefore, factors affecting the real estate value and urban change were taken into consideration and a study was carried out in the central neighborhoods of Selçuklu/Konya. In the study, the data set for 2012 and 2018 was created by collecting a total of 15 criteria of demographic factors and environmental factors, structural change and land-use change factors in Selçuklu/Konya 25 central neighborhoods. The created data set was arranged and the models with three different cluster was tested according to multiple linear regression. The R-1 and R-2 models were the models that could predict the most successful purchase-sale density with 0,875 R^2. However, the result of the comparison of the success criteria of the R-3 model does not mean that this model is not suitable. The following conclusions can be drawn from these models: The increase in population and housing construction area means that the rate of purchase/sale decreases.

It is known that many different factors affect the value of real estate appraisal. Although some factors do not seem to directly affect the value many interrelated factors affect value. There are no standard criteria/feature for real estate valuation in Turkey. In previous applications, economic and demographic data were not used much. This application was carried out to see how the land use classes of demographic and economic data affect the value. According to the factors, it is seen that the highest impact is the housing construction area. Population, on the other hand, have a high negative impact.

According to the research results, the decision-makers will be able to find out what they should do according to the effectiveness of factors, thanks to the model created to predict or manage purchase/sale activity of real estate. Besides, it will be used to regulate the house taxes of local governments. The most important thing is that even though market values are not used in the value estimates of housing, purchase/sale density can be used because it is a factor that reflects the value.

REFERENCES

Andersson, D.E., Shyr, O.F., Fu, J. 2010. Does High-Speed Rail Accessibility İnfluence Residential Property Prices? Hedonic Estimates From Southern Taiwan. J. Transp. Geogr. 18, 166–174.

Bowes, D.R., Ihlanfeldt, K.R. 2001. Identifying the Impacts of Rail Transit Stations on Residential Property Values. J. Urban Econ. 50, 1–25.

Brander, L.M., Koetse, M.J. 2011. The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. J. Environ. Manag. 92, 2763–2773.

Corielli, F., Frigieri, P., Messori, A., Tedeschi, P. 1996. Applicazione Della Teoria Dei Prezzi Edonici Al Mercato İmmobiliare Milanese. In Economia E Pianificazione Della Città Sostenibile; Camagni, R., Ed.; Mulino: Bologna, Italy, 123–144.

Czembrowski, P., Kronenberg, J. 2016. Hedonic Pricing And Different Urban Green Space Types And Sizes: Insights İnto The Discussion On Valuing Ecosystem Services. Landsc. Urban Plan. 146, 11–19.

Erdem N., 2017. Toplu (Küme) Değerleme Uygulama Örnekleri ve Ülkemiz İçin Öneriler, TMMOB Harita ve Kadastro Mühendisleri Odası, 16. Türkiye Harita Bilimsel ve Teknik Kurultayı, 3-6 Mayıs 2017, Ankara.

Fletcher, M., Gallimore, P., Mangan, J. 2000. The modelling of housing submarkets. J. Prop. Invest. Financ. 18, 473–487.

Jahanshiri, E., Buyong, T., Shariff, A.R.M., 2011. A Review of Property Mass Valuation Model, Pertaika J. Sci. & Technol., 19, 23-30.

Konya, 2021. Konya hakkında genel bilgiler. (http://www.konya.com.tr/genel-bilgiler/) Accessed 15 Apr. 2021.

Limsombunc, V., Gan, C., Lee, M. 2004. House Price Prediction: Hedonic Price Model vs. Artificial Neural Network. Am. J. Appl. Sci. 1, 193–201.

Locurcio, M., Morano, P., Tajani, F., Di Liddo, F. 2020. An İnnovative GIS-Based Territorial İnformation Tool For The Evaluation Of Corporate Properties: An Application To The Italian Context. Sustainability, 12(14), 5836.

Lutzenhiser, M. Netusil, N.R. 2001. The Effect of Open Spaces on a Home's Sale Price. Contemp. Econ. Policy 19, 291–298.

Netusil, N.R., Levin, Z., Shandas, V., Hart, T. 2014. Valuing green infrastructure in Portland, Oregon. Landsc. Urban Plan. 124, 14–21.

Noor, N. M., Asmawi, M. Z., & Abdullah, A. 2015. Sustainable Urban Regeneration: GIS and Hedonic Pricing Method in determining the value of green space in housing area. Procedia-Social and Behavioral Sciences, 170, 669-679.

Özkan, G., Yalpır, Ş. 2005. Taşınmaza ekonomik bakış ve değerlendirmesi, TMMOB Harita ve Kadastro Mühendisleri Odası, 10.

Pagourtzi, E., Assimakopoulos, V., Hatzichristos, T., French, N. 2003. "Real estate appraisal: A review of valuation methods", Journal of Property Investment & Finance, 21 (4), 383-401.

Rosen, S. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. J. Polit. Econ, 82, 34–55.

Sheppard, S. 1997. The Welfare Economics of Land Use Regulation; London School of Economics, Department of Geography: London, UK.

Yalpır, Ş., Ünel, F. B., 2016. Türkiye'de Ve Uluslararası Çalışmalarda Arsa Değerlemede Kullanılan Kriterlerin İrdelenmesi Ve Faktör Analizi İle Azaltımı, Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, 16(2), 303-322.

Yomralıoğlu,T., Nişancı,R., Çete,M., Candaş,E. 2011. "Dünya'da ve Türkiye'de taşınmaz değerlemesi", Türkiye'de Sürdürülebilir Arazi Yönetimi Çalıştayı, 26-27 Mayıs 2011, Okan Üniversitesi, İstanbul.