Advanced GIS

http://publish.mersin.edu.tr/index.php/agis/index

e-ISSN:2822-7026

Regression analysis and use of artificial neural networks in housing valuation forecasting: case example of Güvenevler neighbourhood in Mersin

Rabia Nagehan Bekçi*[1], Özcan Zorlu[2], Eda Menekşe[1]

[1]*Mersin University, Institute of Science, Department of Remote Sensing and Geographical Information Systems, Mersin, Turkey*
[2]*Mersin Provincial Directorate of National Education, Mersin, Turkey*

Keywords
Land Management,
Real Estate Valuation,
Regression Analysis,
Artificial Neural Networks (ANN)

Research Article
Received: 28/04/2022
Revised: 28/05/2022
Accepted: 03/06/2022
Published: 25/06/2022

ABSTRACT

Real estate valuation is the process of determining the value of the real estate made to evaluate the factors related to the properties, use and benefits of the real estate. Along with the developing technologies, real estate valuation processes move to modern evaluation methods. In this study, forecasting models were developed for sale price using Regression and Artificial Neural Networks (ANN) methods by using residential data for sale located Güvenevler neighbourhood in Mersin. In this study, the effects of some physical properties such as age, location, number of rooms, balcony condition, number of bathrooms, gross area, facade of the houses in Güvenevler neighbourhood on sales pricing were investigated. In this study in order to make the data more meaningful, Min –Max normalization was performed and regression and ANN modelling was done. SPSS program was used for regression analysis and Matlab program was used for ANN method. With the developed forecasting model, it is aimed to control the price tracking of the old residential district Güvenevler neighbourhood. According to the results of the study, while the rate of explaining the total variation of the independent variables in the housing prices is 92% in the regression analysis, in the network created with ANN, the ratio of independent variables to explain dependent variables is 93%. Both methods are successful because they give results within certain limits.

1. Introduction

From the ancient times when civilizations emerged to the present, the use of the land and the structures on it (immovable) has kept its importance and has become increasingly popular (Doğan & Yakar, 2018; Ulvi et al., 2020). The right of disposal of the right holder on the immovable has been defined, and the purchase and sale transactions have been placed on a legal basis. At this point, the value of the real estate must be determined to carry out the purchase and sale transaction (Hacıköylü, 2016; Yakar & Mırdan, 2017). This process is expressed as real estate valuation; It is known that buyer-seller satisfaction is important in terms of being a guide for comparable properties (Tekeli, 1996; Arıcı et al., 2002; Aksoy et al., 2010; Pirounakıs, 2013).

Real estate valuation; is the process of determining the value of the real estate by using valid and reliable methods, taking into account all the features of real estate, environmental conditions of use, and current economic indicators (Aydın Esmeray, 1996; Bayraktar, 2019). One of the basic parameters for the correct determination of the real estate valuation is the region where the real estate is located. However, all inputs (information and documents) must be provided completely, and this information must be interpreted and evaluated correctly (Demirarslan, 2005).

In addition, for the valuation to be reasonable, the real estate valuation must be at a level to meet different objectives. These targets are;

- Trading valuation
- Taxation
- Expropriation
- Bank mortgage and lending
- Land privatization.

There are various traditional methods for real estate valuation. Nowadays, with the development of technology, new techniques have been added to the existing methods. Evaluated among the traditional methods; comparison, income and cost methods are still the main methods used for real estate valuation today (Yılmaz, 2019; Özen & Şişman, 2019).

***Corresponding Author**

*(nagehanbekci@gmail.com) ORCID ID 0000–0002–3726-9957
(ozorlumetem@gmail.com) ORCID ID 0000-0001-6037-7983
(menekseda94@gmail.com) ORCID ID 0000-0001-8640-4804

Cite this article

Bekçi, R. N., Zorlu. Ö., & Menekşe, E. (2022). Regression analysis and use of artificial neural networks in housing valuation forecasting: case example of Güvenevler neighbourhood in Mersin. *Advanced GIS*, 2(1), 24-32.

The use of statistical science for the valuation of real estate and the acceptable level of results showed that Statistical Methods can be used in this process (Bulut Nas, 2011; Bozdağ & Ertunç, 2020). Occurring in these two methods; Some problems, such as the different price evaluations made by different experts for real estate, led to the development of alternative valuation methods. These methods are defined as Modern Valuation Methods. Real estate valuation methods are expressed by Yalpır (2007) as in Table 1.

Table 1. Real estate valuation methods

Traditional Valuation Methods	Statistical Methods	Modern Valuation Methods
Comparison	Nominal	Artificial Neural
Income	Multiple	Networks
Cost	Regression	Fuzzy Logic
	Hedonic	Spatial Analysis

It is known that there are problems in the valuation of real estate in Turkey as in the rest of the world (Clayton et al., 2009; Wyman et al., 2011; Uğur et al., 2012; Yayar & Gül, 2014; Erdem, 2017; Demirel et al., 2018; Ünel & Yalpır, 2019; Ünel et al., 2020; Yalpır & Ünel, 2022). Problems such as deficiencies in the legislation or the outdated legislation over time, the differences between the real estate value and the real market conditions cause problems in the real estate valuation. It is known that the vehicles, which are in demand as real estate in Turkey and whose sales transactions are carried out, are residences. As interest in the housing market increases, an increase in value is observed. As the population of Turkey increases, the number of houses built is increasing. For this reason, the demand and supply balance in the market cannot be maintained (Ellibeş & Görmüş, 2018). Therefore, it is the tool with the most problems.

It is important to determine the real estate valuation with objective, accurate and reliable sources. The real estate value, the current value, which emerges as a result of the valuation process, plays a major role in the country's taxation as well as in the purchase and sale of real estate (Işıklı, 2019). The fact that Artificial Neural Networks (ANN) has become a popular method has led to its use in real estate valuation. (Öncül, 2008; Yılmaz et al., 2018; Ulvi & Özkan, 2019; Tabar, 2020). ANN, inspired by the features of the human brain; are computer systems that develop abilities such as deriving, discovering and creating new information through learning, automatically without any help. Realization of these capabilities is very difficult with traditional programming methods. Therefore, ANN can be defined as a computer science developed for the analysis of big data (Öztemel, 2003). ANN is applied for data analysis using similar functional properties of the human brain. Such as learning, optimization, classification, analysis, generalization, association, estimation (Öztemel, 2003).

There are price disparities between homes in the same area that have similar features. When there are price variations, homeowners normally determine the pricing of their homes by comparing them to previous sales and then listing them for sale. Estimating the price of a home is a complicated procedure that involves evaluating several variables. The ANN approach may be used to estimate prices thanks to advances in technology.

The real estate valuation studies carried out using the ANN method in the literature are given below.

Khalafallah (2008) analysed real estate sales by performing ANN forecasting modelling for real estates with eight inputs and one output. As input data in the study; time, average interest rate, percent change in sales volume compared to the previous year, change in house price compared to the previous year, average days the house was on the market, inventory volume, inventory month supply; As the output data, factors such as the ratio of the house between the sales and sales prices (PrDf) were used.

In another study conducted with ANN by Ulvi & Özkan (2019); A model research was carried out to determine the real estate values. In this study, models were created by applying ANN and Fuzzy Logic methods to the collected data. It was determined that the calculation made with ANN gave results closer to the correlation value and it was stated that ANN was a more suitable method.

In the study of Kang et al. (2020), estimation models were developed with artificial intelligence and statistical methods by using the prices of the houses sold by the auction method in Seoul. In their study, they used 33 independent variables, including auction sales prices as dependent variables, 7 auction data, 14 physical data and 12 economic data. As a result of the analysis, they found that the auction valuation price was the most effective variable.

The goal of this research is to develop an estimating system for evaluating houses for sale in Mersin's Güvenevler District by employing the ANN approach.

2. Material and Method

2.1. Study area

In this study, the test area was determined as Güvenevler neighbourhood in Yenişehir district of Mersin province (Figure 1). It was named Güvenevler neighbourhood, which was previously connected to the Bahçelievler District, then separated due to the rapid increase in the population with the establishment of Forum mall. Dumlupınar street, 20. street, 1. street, 18. street, Huseyin Okan Merzeci Boulevard (2nd Ring Road) and Gazi Mustafa Kemal Boulevard pass through it. It is the biggest neighbourhood of Yenişehir district. It is the 6th largest neighbourhood in the city centre. Forum mall covers 13% of the neighbourhood. The neighbourhood is located in the middle of the city centre. The distance of the neighbourhood to the sea varies between 350 meters and 1.83 km.

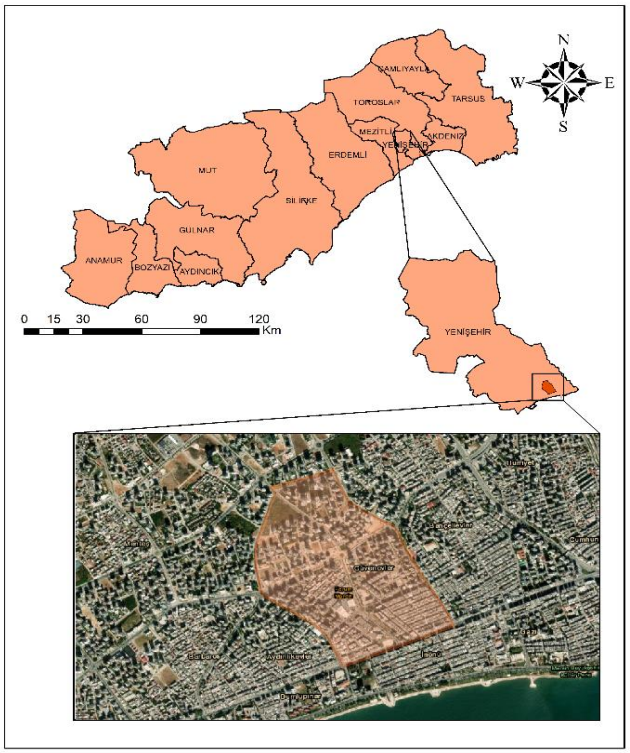

Figure 1. Güvenevler neighbourhood location map

The reason for choosing Güvenevler neighbourhood is that it is close to the biggest shopping centre in the province and the prices are suitable data for the model in housing purchases and sales.

2.2. Data used

The housing data selected in the study consists of 70 houses that were put up for sale from online market platforms in February and March 2020.

Table 2. Variables used in the study

The dependent variable	Independent variables	Usage
Price of the house (F)	Land area	Square meters
	Gross area	Square meters
	Location of the floor	Lower-Middle-Upper floor
	Number of rooms	1+1,2+1,3+1 and above
	Building Age	0-30 years old
	Building floors	1 and above
	Floor location	Ground and above
	Number of facades	1, 2, 3, 4
	Heating Type	Natural Gas and Other
	Number of balconies	1,2,3,4
	Number of bathrooms	1 and above
	Site status	Yes or No
	Pool status	
	Elevation status	
	Security status	
	Generator status	
	Parking status	
	Social area status	
	Concierge status	

Attributes of residences; plot area, gross area, location, number of rooms, building age, number of floors, floor, number of facades, type of heating, number of balconies, number of bathrooms, site, pool, elevator, security, generator, parking lot, social area, concierge and price consist of variables. Table 2 shows the dependent and independent variables of the study.

2.3. Methods used

Within the scope of the study, by applying Min-Max normalization methods to the raw data set, SPSS multiple regression analysis and using Matlab 2018 program, feed-forward backpropagation algorithm from artificial neural network models, and trainlm (Levenberg-Marquardt backpropagation) algorithm as training algorithm, price prediction was made.

2.3.1. Normalization methods

In multiple regression analysis and artificial neural networks, the data can be converted into a better form and used by applying normalization methods to the inputs and outputs. There are different techniques in normalization operations. In the study, raw data were normalized using Min-Max and Z-score rules.

Z-score normalization rule:

$$X' = \frac{X_i - u_i}{\sigma_{\mathrm{i}}} \quad (1)$$

In this equation;

$X^{'}$ = normalized data

$X_i =$ Input value

$u_i =$ Average the input set

$\sigma_i =$standard deviation of the input set represents.

The Min-Max method linearly normalizes the data. The Min-Max rule is:

$$X' = \frac{X_i - X_{min}}{X_{\max} - X_{min}} \quad (2)$$

In this equation;

$X^{'}$ = normalized data

$X_i =$ Input value

$X_{min} =$ The smallest number in the input set

$X_{max} =$ The smallest number in the input set represents.

2.3.1 Multiple linear regression analysis

Multiple regression analysis, which is one of the mass real estate valuation methods, is the most widely used statistical analysis method in the literature. Multiple Linear Regression (CLR) Analysis, on the other hand, is used for model validation of methods such as artificial neural networks, fuzzy logic, genetic algorithms in mass real estate valuation (Yeşim & Tokgöz, 2021; Tabar et al., 2021). In multivariate regression analysis,

the independent variables simultaneously try to explain the change in the dependent variable.

Mathematical model of CLR analysis:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_k X_{ik} + u_i \qquad (3)$$

Y_i = Dependent variable (value of real estate)
$X_{i1}, X_{i2}, \ldots, X_{ik}$ =Its arguments (shares, area, TAKS, KAKS, number of floors, … etc.)
u_i =Distortion or error term
β_0 = constant coefficient
$\beta_1, \beta_2, \ldots, \beta_k$ = variable coefficients
represents.

2.3.2. Artificial neural networks (ANN)

The basic unit of artificial neural networks is the processing element or the artificial neural, which is called a neuron. As seen in Figure 2, the inputs are indicated by the X symbol. After each of these inputs is multiplied by the weight W, the threshold value is added to the Q, and the output f(x) is found by processing with the event function to generate the result. The learning success of an artificial neural network depends on the appropriate adjustment of the weights in the model (Elmas, 2003).

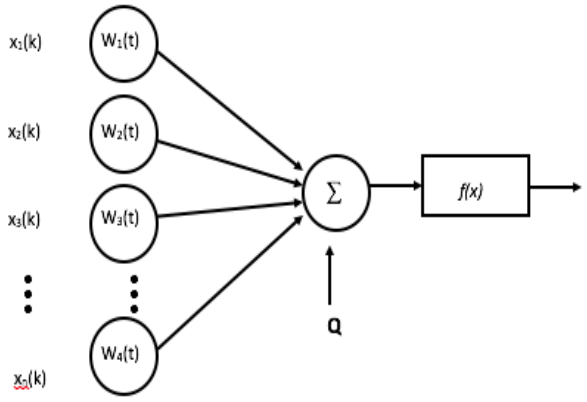

Figure 2. A neuron structure in Artificial Neural Networks (Elmas, 2003)

Although many neural networks are mentioned in the artificial neural network literature, feedforward networks are widely used in the estimation of continuous variables such as price. In feedforward networks, information flows from the input layer to the intermediate layers and the output layer. The learning algorithm compares the values to be found in each iteration with the resulting output and organizes the weights. The most common method used for this is the backpropagation algorithm (Alp & Cığızoğlu, 2004). The backpropagation algorithm works by changing the weight value in each neuron to minimize a loss function (Loss function) by using the sample outputs and the values corresponding to the sample inputs in the learning set. In this way, the weight values with the minimum loss for the training set form the ANN model.

3. Results

3.1. Interpretation of the data set

The fundamental frequency analysis of 70 houses obtained in the study is given in Table 3.

Table 3. Fundamental frequency analysis

Variables		Number	Ratio (%)
Gross Area (m²)	0-120	13	18,6
	120-179	25	35,7
	180-229	19	27,1
	230 and +	13	18,6
Location of the apartment	Downstairs	7	10,0
	Mezzanine	48	68,6
	Upstairs	15	21,4
Number of rooms	2+1 room	19	27,1
	3+1 room	33	47,1
	4+1 and +	18	25,7
Building Age	0-4	4	5,7
	5-10	12	17,1
	11-15	12	17,1
	16-20	15	21,4
	21-25	19	27,1
	26 and +	8	11,4
Number of floors	0-4	24	34,3
	5-10	21	30,0
	11 and +	25	35,7
Floor location	0-4	39	55,7
	5-10	19	27,1
	11 and +	12	17,1

When we examined Table 3, it was seen that the ratios of the data were close to each other. The ratio of flats with a gross area of 120-179 for sale is 35.7%, the ratio of apartments on the mezzanine floor is 68.6%, the ratio of apartments with 3+1 rooms is 47.1%, the ratio of apartments with a building age between 21 -25 years old It is seen that 27.1%, the rate of apartments with 11 floors and above is 35.7%, and the rate of apartments between 0-4 floors is 55.7%.

According to the data obtained, it has been determined that the most popular flats for sale in Mersin Güvenevler District are in the range of 120-179 m2, with 3+1 rooms, in the age range of 21-25, in the range of 0-4 floors.

3.2. Multiple regression analysis

Data for 70 residences collected is life with Min-Max normalization adjustments 0-1. Averages of normalization values and standard deviation values are given in Table 4.

The independent variables determined in the study (value of the house, gross area, location of the flat, number of rooms, age of the building, coefficient, the floor where it is located, facade, heating, number of balconies, number of bathrooms, site, pool, elevator, security, generator, parking lot, social area and The house price variable changes by 9.2 percent (0.920x100) depending on the doorman. As seen in Table 5, the predictive power of the equation was found to be 92%.

Table 4. The mean and standard deviation of the variables

Variables	Mean	Standard Deviation
The value of the residence	,088	,144
Gross area	,156	,155
location of the apartment	,429	,279
Number of rooms	,271	,254
Building Age	,460	,275
Number of floors	,358	,237
Floor location	,218	,236
Facade	,543	,214
Heating	,460	,502
Number of balconies	,514	,185
Number of bathrooms	,100	,172
Site	,460	,502
Pool	,210	,413
Elevation	,660	,478
Security	,310	,468
Generator	,300	,462
Parking	,530	,503
Social area	,310	,468
Doorman	,370	,487

Table 5. Model summary

R	R^2	Adjusted R^2	Estimation of Standard Error
,959	,920	,892	,0473

The obtained Anova test analysis data are shown in Table 6. When the table is examined, it is seen that the significance level, where the F value is 32,648, is significant according to p<0.01. In this context, it can be said that the model created is a meaningful model.

Table 6. Anova test analysis

Model	Sum of squares	df	Avg. of Squares	F	Meaningfulness
Regression	1,314	18	,073	32,648	,000[b]

The findings regarding the relationship between the parameters of the model affecting the house price and the house price are shown in Table 7.

Table 7. Table of coefficients of the model

Variables	Coefficients	Standard error	T	Sig.
Constant	,028	,037	,770	,445
Gross Area(B)	,896	,083	10,814	,000
Position(K)	,013	,027	,477	,635
Number of Rooms(O)	-,127	,054	-2,348	,023
Building Age(Y)	-,106	,041	-2,603	,012
Parameter(K)	,154	,077	2,012	,050
Floor (BK)	,051	,049	1,037	,305
Facade (C)	,043	,043	1,004	,320
Heating (I)	-2,037E-005	,021	-,001	,999
Number of balconies (BS)	-,091	,046	-1,974	,054
Number of bathrooms (BA)	-,119	,063	-1,885	,065
Site (S)	,001	,026	,021	,983
Pool (H)	,016	,047	,344	,733
Elevation (A)	-,044	,022	-1,943	,058
Security (G)	,010	,049	,197	,845
Generator (J)	-,015	,036	-,423	,674
Parking (OT)	-,029	,025	-1,157	,253
Social area (SA)	,030	,032	,928	,358

When the P values given in Table 7 were examined, it was seen that the gross area was statistically significant according to the p<0.01 level. The housing price equation obtained from the model and the findings obtained are as follows.

$$\boldsymbol{Housing\ Price}\ (\boldsymbol{F}) = 0.28 + 0.896 * B + 0.13 * \mathrm{K} - 0.127 * \mathrm{K} - 0.106 * \mathrm{Y} + 0.154 * \mathrm{K} + 0.51 * \mathrm{BK} + 0.43 * \mathrm{C} - 2.037 * \mathrm{E} - 0.05 * \mathrm{I} - 0.97 * \mathrm{BS} - 0.119 * \mathrm{BA} + 0{,}001 * \mathrm{S} + 0{,}016 * \mathrm{H} - 0.044 * \mathrm{A} + 0.010 * \mathrm{G} - 0.015 * \mathrm{J} - 0.029 * \mathrm{OT} + 0.030 * \mathrm{SA} - 0.04 * \mathrm{K} \quad (4)$$

3.3. Artificial neural network prediction modeling

In this study, the Matlab program was used for ANN analysis. Feedforward backpropagation algorithm was preferred as the network type and trainlm (Levenberg-Marquardt backpropagation) algorithm was preferred as the training algorithm. The ANN architecture used in the study is shown in Figure 3. There are 18 inputs, 10 neuron numbers in the hidden layer, and an output layer.

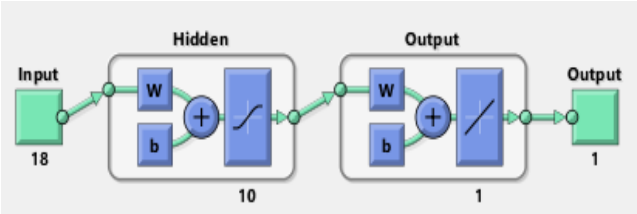

Figure 3. Model of the network

A total of 70 rows of data were used in this study, of which 48 (70%) were used for training, 11 (15%) for testing, and 11 (15%) for validation (Figure 4). The number of hidden neurons used in the network was determined as 25. This ANN was trained with the Levenberg-Marquardt method.

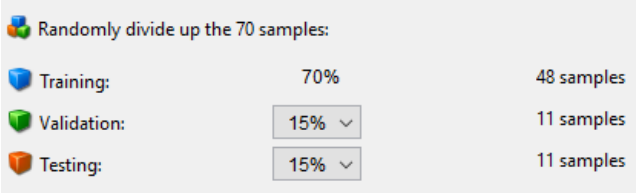

Figure 4. Distribution of ANN training-validation and test data

When the training process was completed, the results shown in Figure 5 were obtained.

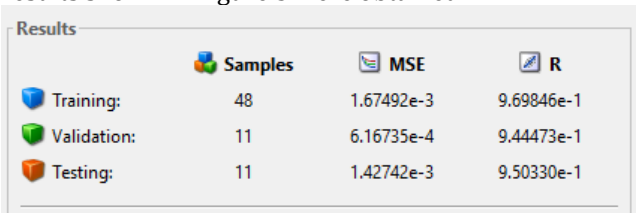

Figure 5. Results obtained

MSE-Minimum squared error is the mean squared difference between outputs and targets. Lower values are better. Zero does not mean error. R-Regression R measures the correlation between outcomes and goals. If

the R-value is 1, it means close relationship, and 0 means random relationship.

When the obtained values are examined; the R-value of the training data is 0.969 and the R2 value is 0.940; verification data R-value is 0.944 and R2 is 0.89; According to the regression values obtained, the R-value of the test data is 0.950 and the R2 value is 0.903, it can be said that the estimation is good.

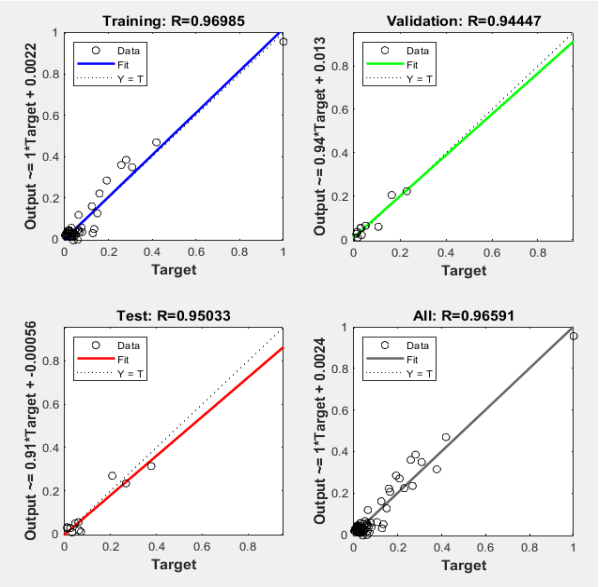

Figure 6. Training, validation, and test scatter curve

As can be seen in Figure 6, the training values are shown for the housing price estimation after a total of 8 iterations. As can be seen, it was determined that the performance of the system was good and it had the best value in the 2nd epoch and the average error rate was 0.000616.

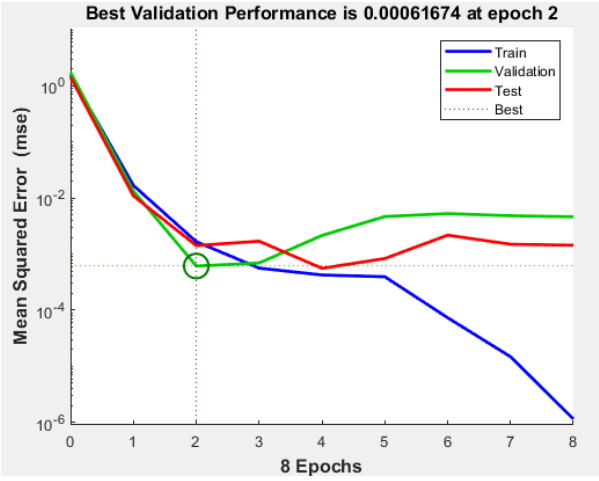

Figure 7. Verification performance

3.3. Comparison of models

The regression analysis model created and the results of the analysis examining the performance of the artificial neural network are given in the table 8.

The mean square error of the generated regression model ranged from -0.037 to +0.037. In the ANN model, it was between -0.029 and +0.029. As a result of the performance evaluation, it is seen that the values estimated by the method using artificial neural networks are less inaccurate.

Table 8. Performance analysis results of the model

Performance Analysis	Regression	ANN
* Average Absolute Percent Error (AAPE)	1,278	0,872
* Mean Square Error (MSE)	0,037	0,0295
* Average Absolute Error (AAE)	0,002	0,001

According to the results obtained, the actual target values (targets) and the outputs obtained from the network and as a result of the regression analysis were compared in Figure 8. When the data is examined, it is seen that both the values obtained from the network and the Regression analysis estimation values are in the appropriate range. While the regression model approaches the price in some plots, it is generally seen that the ANN model is more compatible with the price.

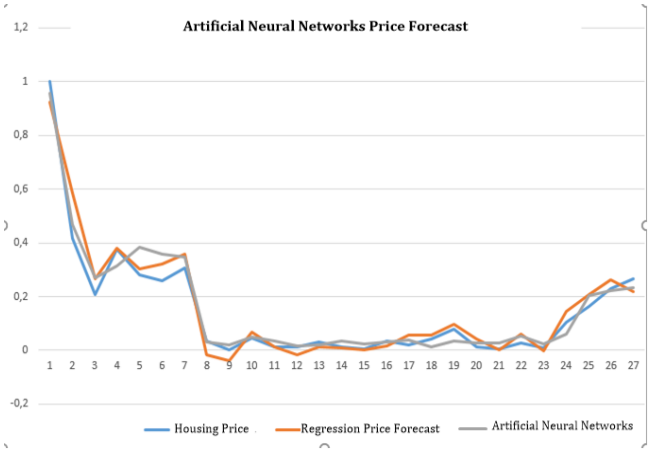

Figure 8. Comparison chart

3.4. Creating value maps

While creating the value map, geographical and descriptive data are associated. Parcel IDs were added to the data with island and parcel numbers, and the data was processed in the ArcGIS program. The current map of Güvenevler District was used as a base. Value map was created by applying Kriging with the geostatistical analysis tool in ArcGIS. The value map created by the ANN method, regression method and normalization is shown in Figure 9. The values of the buildings located in the area close to the 1st ring road of Güvenevler District are low since it is an old settlement area. The values are high as new constructions are seen in the area between the 2nd and 3rd ring roads.

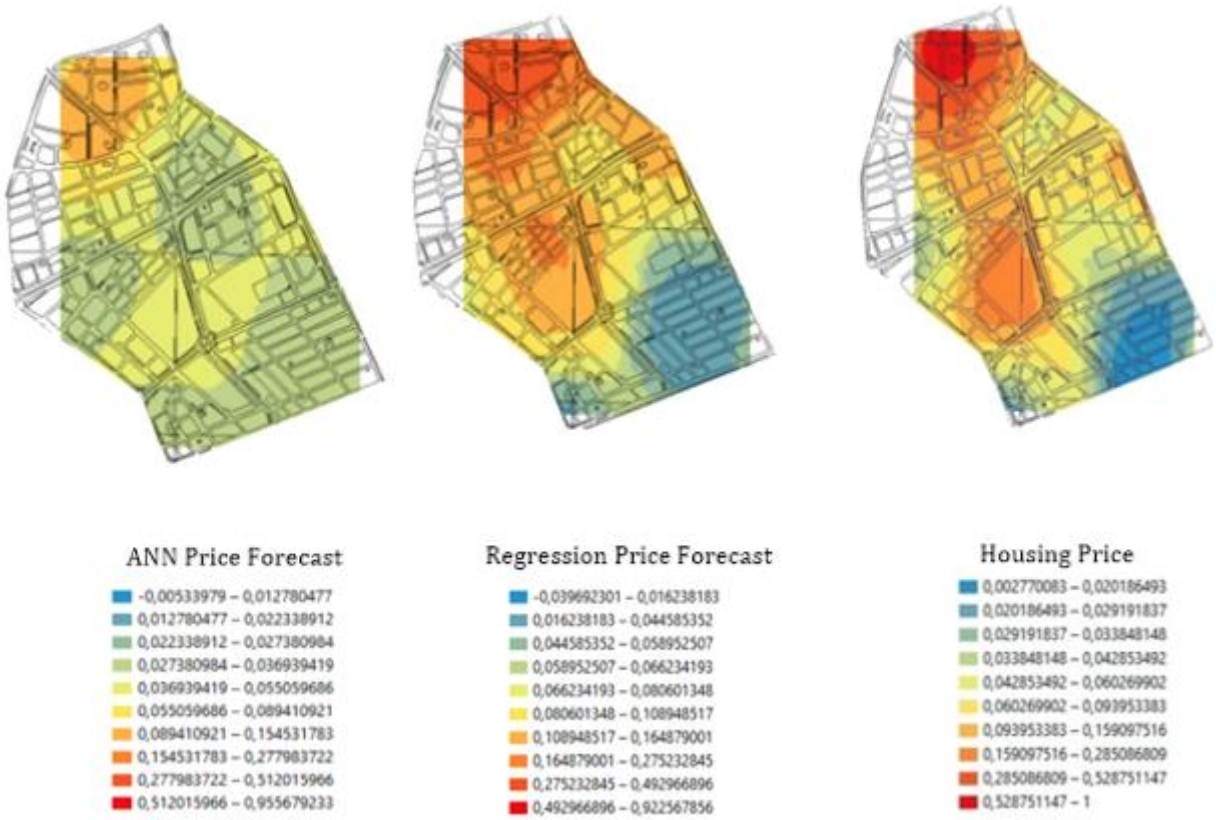

Figure 9. (a) ANN price estimation, (b) Regression price estimation, (c) House price value maps

4. Conclusion

A regression and ANN estimation model was developed by using the data of 70 houses for sale in Güvenevler neighbourhood of Yenişehir district of Mersin province. With the estimation model developed, it is aimed to control the price monitoring of the former settlement of Güvenevler neighbourhood.

The results of the study:

- Modeling using the ANN method can make better price predictions than the model made with Regression analysis.
- The performance of the ANN method is better than the regression analysis.
- Both methods are successful because they give results within certain limits.
- In the regression analysis, the ratio of the independent variables to explain the total variation in house prices is 92%, the remaining 8% consists of unknown factors. In the ANN network, it was found that the rate of explaining the dependent variables of the independent variables was 93%.
- We can say that the number of independent variables used in the study is sufficient. There is a high correlation between independent variables and price.
- As a result of the regression analysis, there is a negative correlation (-0.503) between the price and the age of the building. There is a positive correlation in other variables. In other words, as the age of the building increases, the price decreases. The correlation coefficient between price and gross area was found to be 0.913. It was also observed that there is a very strong relationship between them.
- The buildings located in the area close to the 1st ring road of Güvenevler Neighbourhood show low values as they are the old settlement areas, while the values of the real estates are high due to new constructions in the area between the 2nd and 3rd ring road.

Considering the basic attributes of the flat (area, age, location, etc.), it is foreseen that the unjust treatment will be prevented by making a price determination estimate.

Author Contributions

The contributions of the authors of this article is equal

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were complied with in the study.

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