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Land Price Modeling with Radial Basis Function (Case Study: Utan Kayu Selatan Village, East Jakarta)

Sawitri Subiyanto [1]*, Hana Sugiastu Firdaus [1], Nahar Dito Utama Giardi [1]
[1] Departement of Geodetic Engineering, Faculty of Engineering, Diponegoro University
Jl. Prof. Sudarto, SH, Tembalang, Semarang Telp.(024)76480785, 76480788, Indonesia
*Corresponding author e-mail: sawitrisubiyanto66@gmail.com

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Abstract

The price of land is an important matter that needs to be assessed by stakeholders. The study of land prices has an important role in seeing the stability of the property market. Several factors affect the property business such as accessibility, public facilities and social facilities. Utan Kayu Selatan is the largest village in Matraman Sub-District with an area of 1,12 kilometers. The potential of the property business is very tempting for investors to property developers. One of the economic sector developments is Utan Kayu Raya Road, which can increase land prices in the surrounding area. The factors that influence land prices can be analyzed through several approaches such as regression, mass appraisal and other. In this study, the method used in estimating land prices is the Radial Basis Function (RBF), by looking at the relationship between the distance of plot to roads, public facilities and social facilities. Modeling is carried out based on samples determined on ZNT and NJOP land prices. Furthermore, the calculation of the distance is done by using network analysis. As a result, the RMSE value for the NJOP RBF model and the ZNT RBF model is IDR 1.179.839 and IDR 2.972.345. Meanwhile, the CoV values for both models were 6.2% and 6%. In the comparison of ZNT price predictions with market prices, the highest difference is IDR 13.119.915 and the lowest difference is IDR 537.009. While on the NJOP price prediction, the highest difference is IDR 15.797.583 and the lowest difference is IDR 291.270.

Keywords: Land Price, Mathematical Model, RBF

1. Introduction

The study of land prices has an important role in seeing the stability of the property market. The development of land prices is quite volatile in terms of various aspects such as spatial planning, supporting infrastructure and socio-economic policies. Starting from this, property investors, property developers and the government as the regulator must pay attention to the latest land price developments. Land prices can be predicted through various approaches, one of which is the sales comparison approach using regression analysis. Regression analysis is used to predict the value of the dependent variable, such as predicting the selling price of a house containing physical variables, assuming that these physical variables influence the house's selling price (Harjanto & Hidayati, 2003).

Several studies regarding land price prediction approach such as Husna (2016) estimate and simulate land prices using the Radial Basis Function (RBF) with an error output of 32,5% for 16 center points and 23,9% error for 29 center points. Sampathkumar et al. (2015) conducted modeling and prediction of land prices in Chennai Metropolitan Area (CMA), Tamilnadu, India, using multiple linear regression and neural networks. The results obtained are that both models are good, with a correlation of 98% for neural networks and 96% for multiple linear regression.

In this study, researchers conducted land price modeling using the Radial Basis Function (RBF) in Utan Kayu Selatan Village, East Jakarta. Utan Kayu Selatan is the largest village in Matraman Sub-District, East Jakarta, with an area of 1,12 square kilometers (Badan Pusat Statistik Jakarta Timur, 2018). The wide coverage area is certainly advantageous for property investors to developers in property investment, supporting easily accessible facilities. Based on rumah.com, the development of residential land prices in East Jakarta ranks the highest compared to other Jakarta cities with a growth of up to 5,58% per year. The development of land prices is influenced by factors such as accessibility, public facilities and social facilities. This influence can be determined through a mathematical model so that stakeholders can ascertain the factors that affect land prices in this village.

This study uses a variable distance from each plot of land to the facility. The property distance variable to the city center is one of the variables taken into account in predicting land prices (Truong et al., 2020). Therefore, the distance calculation is carried out using road network analysis in the hope that it can represent the situation in the field.

The researcher hopes that the mathematical model of land prices can be considered by stakeholders in making a policy and can be developed according to the research location's current conditions.

2. Material and Methods

2.1. Data

The data used in the research include NJOP Data for Utan Kayu Selatan Village in 2019, the PBB Block Map for the Utan Kayu Selatan Village in 2015, the Land Value Zone Map for the Utan Kayu Selatan Village in 2017, the Detailed Spatial Plan Map for Matraman Sub-District and the field survey. The difference in years in this study shows that the data used varies, so it is necessary to update it.

2.2. Sample Determination

The sample determination is based on the Slovin formula (Amirin, 2011; Tejada & Punzalan, 2012).

$$n = \frac{N}{1+Ne^2} \quad (1)$$

where:

n : number of samples
N : population size
e : error tolerance

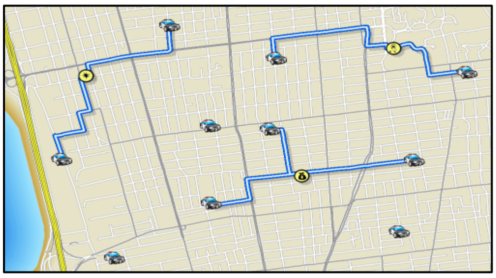
The sample is determined based on two criteria: the proportion of the plot to the zone and the proximity of the zone to the parameters (accessibility, public facilities and social facilities). Then the weighting was carried out using Slovin for each zone.

Figure 1. Distribution of Land Price Model Samples

The variables of roads, public facilities and social facilities were selected based on the level of influence of these variables on the socio-economic conditions in the research location.

2.3. Distance Calculation

The distance calculation is done by measuring the distance between the center point (centroid) of the plot of land and the parameter's centroid. So the researcher needs to know the centroid of the plot and the centroid parameter first, then calculate the distance using the closest facility feature. The closest facility is a solution in measuring travel costs between the incident and facilities by determining each other's closest distance. The closest facility displays the best route between the incident and facilities and reports travel expenses and travel (ESRI, 2020).



Source: ESRI Website

Figure 2. Illustration of Closes Facility

2.4. Land Price Modeling

The mathematical model of land prices is determined using sample distance data to parameters, NJOP sample price and ZNT sample price. The initial step that must be done is to determine the spread value using a formula (Wiyanti & Pulungan, 2012).

$$\sigma = \frac{d_{max}}{\sqrt{m}} \quad (2)$$

where:

σ : spread value
d_{max} : the maximum distance between two centroid
m : the number of the centroid

Based on formula ($\sigma = \frac{d_{max}}{\sqrt{m}}$ (2), the spread value obtained for this study is 1419,276. Next, compile a Gaussian matrix that contains the sample Gaussian basis functions against the parameters. Gaussian basis functions are well represented in many branches of mathematics (Fasshauer, 2007). If the Gaussian base function is combined with the euclidean distance function, then the multivariate function is obtained for each center point of $X_k \in \mathbb{R}^s$.

$$\phi_k(X) = e^{-\varepsilon^2\|X-X_k\|_2^2}, X \in \mathbb{R}^s \quad (3)$$

where:

ϕ_k : Gaussian basis function
ε^2 : RBF parameter's
X : input vector
X_k : centroid vector

The sample used in building the RBF model of land prices is 371, with a total parameter of 25. So that the Gaussian matrix illustration can be seen in Figure 3.

$$A = \left(\begin{bmatrix} \varphi_{11} & \varphi_{12} & \varphi_{13} & \varphi_{14} & \varphi_{15} & \cdots & \varphi_{125} \\ \varphi_{21} & \varphi_{22} & \varphi_{33} & \varphi_{24} & \varphi_{25} & \cdots & \varphi_{225} \\ \varphi_{31} & \varphi_{32} & \varphi_{33} & \varphi_{34} & \varphi_{35} & \cdots & \varphi_{325} \\ \varphi_{41} & \varphi_{42} & \varphi_{43} & \varphi_{44} & \varphi_{45} & \cdots & \varphi_{425} \\ \varphi_{51} & \varphi_{52} & \varphi_{53} & \varphi_{54} & \varphi_{55} & \cdots & \varphi_{525} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \varphi_{3711} & \varphi_{3712} & \varphi_{3713} & \varphi_{3714} & \varphi_{3715} & \cdots & \varphi_{37125} \end{bmatrix} \right)$$

Figure 3. Illustration of a Gaussian Matrix

Then the land price matrix is compiled based on the sample. This study uses two data: the ZNT price and the NJOP price, so there are two land price matrices. Furthermore, the calculation of the RBF coefficient using the least square. RBF expansion is used to solve data interpolation problems that are scattered in $\mathbb{R}^n$ (Fasshauer, 2007). The coefficient of each independent variable is obtained using interpolation through the least square approach.

$$X = (A^T.A)^{-1} A^T.F \tag{4}$$

where:
X : the coefficient of each independent variable
A : Gaussian matrix
F : land price matrix

So that the mathematical model of land prices in this study is like Equation ($s(X) = \sum_{k=1}^{n} \lambda_k e^{-\varepsilon^2 \|X-X_k\|_2^2}, X \in \mathbb{R}^n$ (5).

$$s(X) = \sum_{k=1}^{n} \lambda_k e^{-\varepsilon^2 \|X-X_k\|_2^2}, X \in \mathbb{R}^n \tag{5}$$

where:
$s(X)$: RBF function
λ_k : the coefficient
ε^2 : RBF parameter's
X : the plot centroid's
X_k : parameter centroid's

2.5. Model Accuracy Test

The mathematical model of land prices is evaluated using the Root Mean Square Error (RMSE) and the Coefficient of Variation (CoV). RMSE is the root mean of the difference between the output and the actual data. The RMSE value is getting closer to zero, indicating that the variation in the value generated by an approximate model is close to the variation in its observation value. The following is the RMSE formula (Buwana,2006).

$$RMSE = \sqrt{\frac{\sum(Hh-Ha)^2}{n}} \tag{6}$$

where:
Hh : prediction of land price
Ha : actual land price
n : the amount of data

Meanwhile, CoV is a statistical standard measuring the relative dispersion of a sample about the data's mean. It is expressed as a percentage of the average (International Association of Assessing Officers, 2013). Models with a CoV value below 5% are said to be very good, but in general, a model is said to be good if the CoV is 7% - 10% (Linne et al,2000).

2.6. Stage of Research

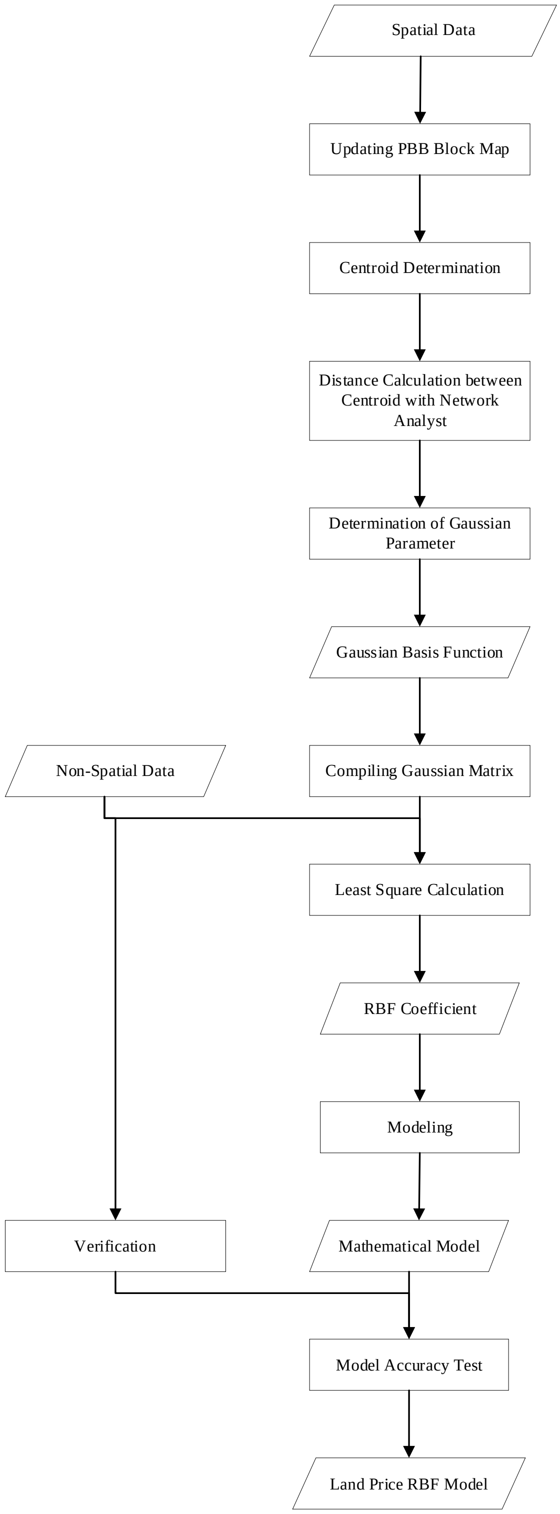


Figure 4. Research Flow

3. Result and Discussion

3.1. Land Price RBF Model

The following is a mathematical model of land prices for ZNT and NJOP.

$$\begin{aligned} s(\mathrm{X})NJOP = {} & 252300423,634\, e^{-\varepsilon^2\|X-X_1\|_2^2} - 218741959,923\, e^{-\varepsilon^2\|X-X_2\|_2^2} \\ & + 4931031,727\, e^{-\varepsilon^2\|X-X_3\|_2^2} + 19063803,185\, e^{-\varepsilon^2\|X-X_4\|_2^2} \\ & - 6836669,017\, e^{-\varepsilon^2\|X-X_5\|_2^2} + 39165073,145\, e^{-\varepsilon^2\|X-X_6\|_2^2} \\ & + 19412196,765\, e^{-\varepsilon^2\|X-X_7\|_2^2} - 61570656,491\, e^{-\varepsilon^2\|X-X_8\|_2^2} \\ & + 28543521,049\, e^{-\varepsilon^2\|X-X_9\|_2^2} - 68797311,990\, e^{-\varepsilon^2\|X-X_{10}\|_2^2} \\ & + 67224493,978\, e^{-\varepsilon^2\|X-X_{11}\|_2^2} + 14066773,960\, e^{-\varepsilon^2\|X-X_{12}\|_2^2} \\ & + 30601954,456\, e^{-\varepsilon^2\|X-X_{13}\|_2^2} - 40790900,618\, e^{-\varepsilon^2\|X-X_{14}\|_2^2} \\ & + 14361538,247\, e^{-\varepsilon^2\|X-X_{15}\|_2^2} - 4790455,411\, e^{-\varepsilon^2\|X-X_{16}\|_2^2} \\ & + 38297024,027\, e^{-\varepsilon^2\|X-X_{17}\|_2^2} + 4785263,605\, e^{-\varepsilon^2\|X-X_{18}\|_2^2} \\ & - 50522579,350\, e^{-\varepsilon^2\|X-X_{19}\|_2^2} - 5181587,524\, e^{-\varepsilon^2\|X-X_{20}\|_2^2} \\ & + 441198,166\, e^{-\varepsilon^2\|X-X_{21}\|_2^2} + 12732823,331\, e^{-\varepsilon^2\|X-X_{22}\|_2^2} \\ & - 1633658,380\, e^{-\varepsilon^2\|X-X_{23}\|_2^2} - 16850481,429\, e^{-\varepsilon^2\|X-X_{24}\|_2^2} \\ & - 21019526,017\, e^{-\varepsilon^2\|X-X_{25}\|_2^2}, \qquad \varepsilon^2 = 0,00000025 \end{aligned}$$

(a)

$$\begin{aligned} s(X)ZNT = {} & 885156101,231\, e^{-\varepsilon^2\|X-X_1\|_2^2} - 842000652,706\, e^{-\varepsilon^2\|X-X_2\|_2^2} \\ & + 74854171,171\, e^{-\varepsilon^2\|X-X_3\|_2^2} - 20042553,625\, e^{-\varepsilon^2\|X-X_4\|_2^2} \\ & + 26025057,396\, e^{-\varepsilon^2\|X-X_5\|_2^2} - 57452864,391\, e^{-\varepsilon^2\|X-X_6\|_2^2} \\ & + 2590531,255\, e^{-\varepsilon^2\|X-X_7\|_2^2} - 28157735,133\, e^{-\varepsilon^2\|X-X_8\|_2^2} \\ & - 34840833,076\, e^{-\varepsilon^2\|X-X_9\|_2^2} - 269483342,318\, e^{-\varepsilon^2\|X-X_{10}\|_2^2} \\ & + 219429885,143\, e^{-\varepsilon^2\|X-X_{11}\|_2^2} + 39430668,873\, e^{-\varepsilon^2\|X-X_{12}\|_2^2} \\ & + 79331842,121\, e^{-\varepsilon^2\|X-X_{13}\|_2^2} - 94454780,418\, e^{-\varepsilon^2\|X-X_{14}\|_2^2} \\ & + 71911297,441\, e^{-\varepsilon^2\|X-X_{15}\|_2^2} - 18009852,715\, e^{-\varepsilon^2\|X-X_{16}\|_2^2} \\ & + 72628171,838\, e^{-\varepsilon^2\|X-X_{17}\|_2^2} - 200917858,810\, e^{-\varepsilon^2\|X-X_{18}\|_2^2} \\ & - 44029934,225\, e^{-\varepsilon^2\|X-X_{19}\|_2^2} - 1630617,301\, e^{-\varepsilon^2\|X-X_{20}\|_2^2} \\ & - 60509609,125\, e^{-\varepsilon^2\|X-X_{21}\|_2^2} + 293489874,071\, e^{-\varepsilon^2\|X-X_{22}\|_2^2} \\ & + 26470924,053\, e^{-\varepsilon^2\|X-X_{23}\|_2^2} - 3885186,460\, e^{-\varepsilon^2\|X-X_{24}\|_2^2} \\ & - 21936940,268\, e^{-\varepsilon^2\|X-X_{25}\|_2^2}, \qquad \varepsilon^2 = 0,00000025 \end{aligned}$$

(b)

Figure 5. RBF Model (a) NJOP, (b) ZNT

The RBF model of land prices is compiled using 371 samples with 25 independent variables. After the model is obtained, an evaluation of the model is carried out using RMSE and CoV. Model evaluation is done by determining the RMSE and CoV based on the 371 samples used to obtain the results in Table 1.

Table 1. Evaluation of the RBF Model based on RMSE and CoV

`	NJOP RBF Model	ZNT RBF Model
RMSE	IDR 1.179.839	IDR 2.972.345
CoV	0,062	0,060

The RMSE value of the RBF NJOP model has a smaller value than the RBF ZNT model. This shows that the NJOP RBF model has a lower error rate when used to predict NJOP prices. However, both models have a CoV value in the range of 7% -10%, so that both models have good quality.

3.2. Prediction Modeling Results

The land price RBF model is used to predict NJOP and ZNT prices in Utan Kayu Selatan. The initial step is to predict 371 samples and then perform a spatial join with the search distance criteria of 200 meters to fill all land plots with predicted values.

Figure 6 shows that the highest NJOP price prediction is around Jenderal Ahmad Yani Road with more than IDR 6.500.000. Meanwhile, around Kayu Manis Timur Road (west side) the predicted value is in the range of IDR 5.500.000 to IDR 6.500.000. The predicted value around Pisangan Baru Utara Road (south side) is in the range of IDR 4.500.000 to 5.500.000. The predicted value is not the same as NJOP but seen from the distribution, it has the same pattern.

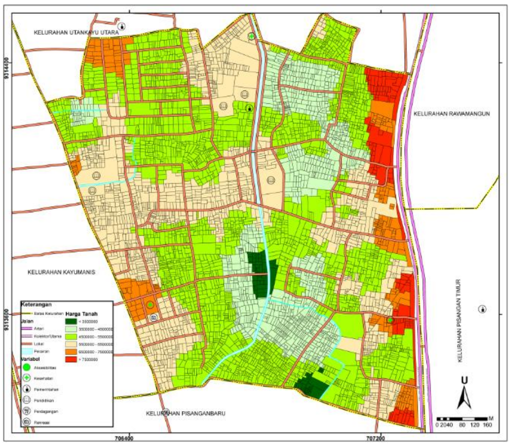


Figure 6. Prediction results based on the NJOP Model

It can be seen in **Figure 7** that the predicted value generated based on the ZNT price is in the range of IDR 12.000.000 to IDR 17.500.000 for the northern part of this village. Meanwhile, for the South, the predicted value is in the range of IDR 6.500.000 to IDR 12.000.000. The highest predicted value remains around Jenderal Ahmad Yani Road. This shows that the range of predicted values generated based on the ZNT price is almost the same as the land value zone in Utan Kayu Selatan Village.

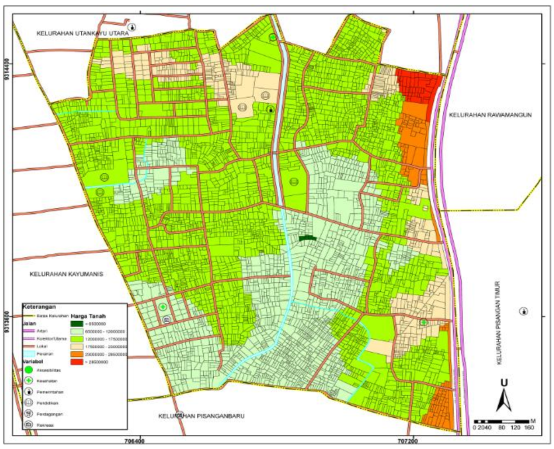


Figure 7. Prediction results based on the ZNT Model

3.3. Comparison of Market Prices with Land Price Predictions

In this study, a market-based land price survey was also conducted. Market price data is used as a comparative analysis of land price predictions. The market data obtained is 51 with the distribution, as shown in Figure 8. It can be seen that market land prices tend to be in the housing zone in the western part of Utan Kayu Selatan Village. This can be caused by accessibility and other factors. The market price data is then entered into the RBF model to obtain land price predictions based on zone and NJOP.

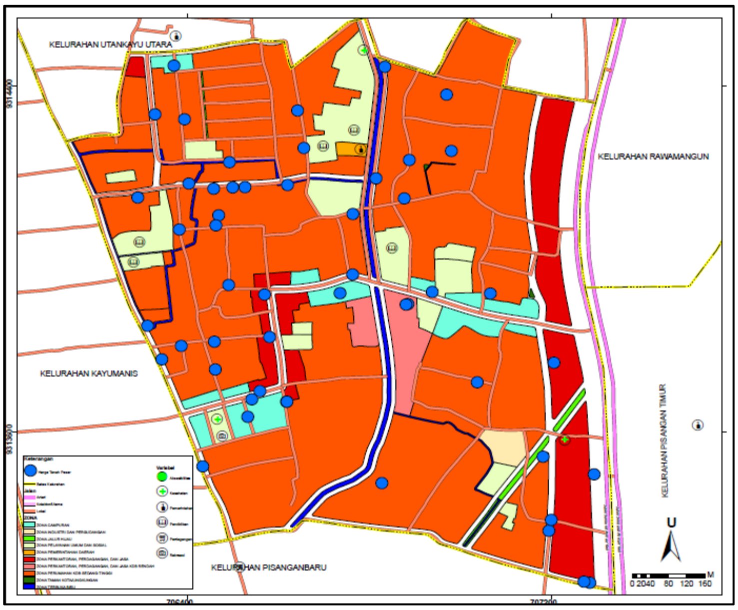


Figure 8. Distribution of Market Land Price Data

Table 2. Comparison of Market Land Prices with Land Price Predictions

Address	Market Land Price		ZNT Price Prediction		NJOP Price Prediction	
Kelapa Sawit Raya	IDR	11.819.256	IDR	10.410.089	IDR	6.270.827
Kelapa Sawit V	IDR	7.068.124	IDR	11.975.572	IDR	6.131.218
Kelapa Tinggi	IDR	8.763.253	IDR	9.571.470	IDR	5.346.928
Kelapa Tunggal	IDR	11.934.497	IDR	14.834.570	IDR	4.962.930
Kelapa Tunggal	IDR	9.247.599	IDR	14.835.921	IDR	4.964.620
Kramat Asem	IDR	17.690.356	IDR	9.143.045	IDR	5.641.246
Kramat Asem	IDR	12.885.710	IDR	13.629.386	IDR	6.473.031
Kramat Raya	IDR	12.807.191	IDR	8.947.610	IDR	5.433.251
Kramat Raya	IDR	6.714.190	IDR	8.867.667	IDR	5.406.974
Moncokerto I	IDR	9.325.822	IDR	11.499.901	IDR	5.936.392
Moncokerto III	IDR	17.050.153	IDR	12.338.508	IDR	5.608.153
Moncokerto Raya II	IDR	12.326.460	IDR	14.125.000	IDR	5.995.626
Nanas	IDR	9.765.354	IDR	15.761.564	IDR	5.662.540
Nanas III	IDR	11.799.364	IDR	16.797.806	IDR	4.666.528
Pandan	IDR	12.797.256	IDR	16.523.634	IDR	5.889.202
Puspa	IDR	14.575.932	IDR	13.235.304	IDR	5.575.686
Rasamala II	IDR	2.613.569	IDR	15.733.484	IDR	5.434.560
Skip Ujung	IDR	12.012.484	IDR	22.128.611	IDR	7.157.392
Skip Ujung	IDR	10.889.532	IDR	17.662.468	IDR	5.556.927
Skip Ujung	IDR	8.550.558	IDR	17.638.260	IDR	5.468.648

Based on the comparison of market land prices with predicted land prices, the difference between the market price and the ZNT price prediction is shown in Table 3.

Table 3. Classification of Differences between Market Land Prices and ZNT Price Predictions

Difference between Market Land Price and ZNT Price Prediction	Frequency
< IDR 1.000.000	6
IDR 1.000.000 – IDR 10.000.000	42
> IDR 10.000.000	3

Difference frequency of more than IDR 10.000.000 is three data. This significant difference can be caused by several factors, one of which is the RCN calculation. Researchers can make mistakes in calculating the RCN so that land prices have a high price difference. As adjacent fields have the same area but the prices offered are quite different. Also, the factor that causes quite a difference is the source of the data. In this study, the data sources used included interviews with owners, agents and the mass media. Sources from agents and mass media can cause calculation errors because the price offered is much higher than the actual price.

Figure 9 shows that the land price offered in the Utan Kayu Selatan Village is generally higher than the NJOP price prediction. The market price offered is indeed higher than the NJOP. Offering prices higher than NJOP is common in the property business.

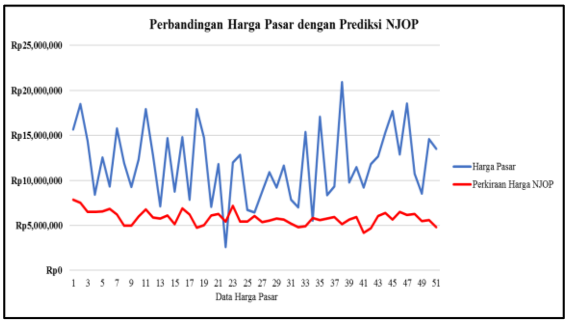


Figure 9. Comparison of Market Land Prices with NJOP Predictions

4. Conclusion

Based on this study's results, it can be concluded that the RBF Model of the NJOP price has an RMSE of IDR 1.179.839 while the ZNT price was IDR 2.972.345. In testing the model's quality using CoV, the CoV values for the NJOP price model and the ZNT price were 6.2% and 6%, respectively.

In the comparison of ZNT price predictions with market prices, the highest difference is IDR 13.119.915 and the lowest difference is IDR 537.009. Also, three data have a difference between the ZNT price prediction and the market price of more than IDR 10.000.000 and six data have a difference of less than IDR 1.000.000. For comparison of NJOP price predictions with market prices, the highest difference is IDR 15.797.583 and the lowest difference is IDR 291.270. The market price generally has a higher price than the NJOP price and is also valid compared to the NJOP price prediction.

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