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# ANALYSIS OF FACTORS AFFECTING LAND VALUE OF TRANSMISSION TOWER WITH GEOGRAPHICALLY WEIGHTED REGRESSION

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**Abstract**. The development of Electrical Infrastructure in the form of transmission lines for electricity requires land for the location of the tower site. The many locations of tower footprints are spread over a geographical area with different characteristics (spatial heterogeneity) which are thought to affect land values. Spatial heterogeneity is when the estimator parameters give different responses at different locations for the same explanatory variable. This study will determine the factors that affect the value of land on the tower footprint in Galang District using a geographically weighted regression model with a fixed gaussian kernel weighting. This study compares the observed land value with the predicted land value indication using the linear regression model (OLS) and the Geographicly Weighted Regression (GWR) model. This land value modeling uses 4 explanatory variables, namely land distance to the nearest road ($X_1$), land distance from the CBD ($X_2$), land distance to main transportation routes ($X_3$) and land elevation ($X_4$). The results showed that the minimum observation land value was IDR. 78.000 $m^2$ (2021), the minimum GWR model predicted land value is IDR. 85.000/$m^2$ and the minimum predictive land value of the OLS model is IDR. 86.000/$m^2$. While the maximum observation land value is IDR. 130,000 $m^2$, the maximum predicted land value of the GWR model is IDR. 125.000/$m^2$ and the maximum predicted land value of the OLS model is IDR. 123,000/$m^2$. In general, the difference between the GWR model land value and the observed land value is IDR. 5.562/$m^2$ is smaller than the difference in the value of the OLS model land to the observed land value of IDR. 25,020 $m^2$. So in general the GWR prediction soil model is closer to the regression line of the observed land value compared to the OLS model prediction value line. GWR model with fixed kernel weighting function gaussian has an R-square value of 75.98%, AIC -104.63 and a land value difference of IDR. 5.562/$m^2$ with an observation value while the OLS model has an R-square value of 73.74% and AIC -102.80 and the difference in land value is IDR. 25,020/$m^2$ with observation value. So that the GWR model is better than the OLS model in modeling the land value of the tower footprint in Galang.

**Keywords:** Spatial Heterogeneity, Land Value Model, Geographically Weighted Regression, Fixed Gaussian Kernel

## 1. Introduction

The construction of transmission towers as electricity infrastructure that distributes electrical energy to consumers certainly requires a large amount of land for the tower footprint (Li et al., 2022). The increasing demand for land for the construction of this transmission resulted in increased demand for land while supply remained constant. Economically, this has the potential to increase the value of land for the needs of the transmission network construction. In addition to the above economic factors, physical factors also affect the value of the land. Dale and Mc Laughlin (1988) in Kurniyaningsih (2019), stated that the factors that affect the value of land can be divided into internal factors and external factors. Internal factors include the topography of the soil, the nature of the soil, the design and condition of the building. External factors include external influences covering the land location environment, such as transportation facilities, new community activity centers such as factories/industries, shopping centers, terminals and others (Idham et al., 2018 and Ramadhan, 2022). Previous research on the influence of physical factors both internal and external on land values has been carried out by Tarmizi et al (2017), Karakayaci (2018), Bintang, et. al. (2019), Kurniyaningsih (2019), Mardiana et al (2022) using ordinary least squares (OLS). Prasetya and Sunaryo (2013) conducted a study using factor analysis in the form of a correlation matrix between variables. In the studies above, the assumption is that there is no spatial heterogeneity in adjacent locations. The number of needs for the location of tower footprints that are spread over a geographical area with different characteristics (spatial heterogeneity), is thought to affect the value of the land. Spatial heterogeneity is when the estimator parameters give different responses at different locations for the same explanatory variable. This study aims to determine the spatial effect of the factors that affect the value of the land on the tower footprint in Galang District using a geographically weighted regression (GWR) model with a fixed gaussian kernel weighting. GWR is a linear regression by adding weighting parameters of predictor variables at each location.

## 2. Literature Review

### 2.1. Ordinary Least Square (OLS)

Ordinary Least Square is a multiple linear regression which is a model of the relationship between response variables y and predictor variables $x_1$, $x_2$, ,..., $x_p$. The linear regression model for the predictor variable $p$ with $y_i$ as the predictive value is generally written as follows:

$$y_i = \beta_0 + \sum_{k=1}^{p} \beta_k x_{ik} + \varepsilon_i \quad (1)$$

Where $\beta_0$ is a constant, $x_{ik}$ is the value of the k-th explanatory variable at location-i, $\beta_k$ is the coefficient value of the explanatory variable, $p$ is the number of explanatory variables used in the model, n is the number of observations, and $\varepsilon_i$ is the random error of the observation at location-i, which is assumed to be normally distributed $N(0,\sigma^2 I)$. In matrix notation it is written as follows:

$$\boldsymbol{Y} = \boldsymbol{X\beta} + \boldsymbol{\varepsilon}$$

For n data points and k influence variables, the β and X matrices will have an effect. estimates for $\hat{\beta}$ are:

$$\hat{\boldsymbol{\beta}} = (\boldsymbol{X}^T\boldsymbol{X})^{-1}\boldsymbol{X}^T\boldsymbol{y} \quad (2)$$

### 2.2. Geographically Weighted Regression (GWR)

The GWR model is a development of the classical linear regression model or Ordinary Least Square (OLR). The GWR model is a regression model developed to model data with continuous response variables and consider spatial or location aspects. The approach taken in GWR is a point approach. Each parameter value is estimated at each point of observation location, so that each point of observation location has different parameter values. This model can be written as follows:

$$y_i = \beta_0(u_1, v_1) + \sum_{k=1}^{p} \beta_k(u_i, v_i) x_{ik} + \varepsilon_i \quad (3)$$

where:

$y_i$ : dependent variable at location-i

$(u_i,v_i)$ : coordinates for location-i

$\beta_0$ $(u_i,v_i)$ : intercept location-i
$\beta_k$ $(u_i,v_i)$ : coefficient for independent variabel k at location-i
$x_{ik}$ : independent variable at location-i
$\varepsilon_i$ : residual location-i with $\varepsilon_i$ ~ $IIDN$ (0, $\sigma^2$).

The estimation of the GWR model uses WLS (Weighted Least Square), namely by giving different weights in each location. The form of the GWR model parameter estimator at each location is:

$$\hat{\beta}(u_i, v_i) = (X^T W(u_i, v_i) X)^{-1} X^T W(u_i, u_i) Y \tag{4}$$

The matrix has the order $\boldsymbol{X}(nx(p+1)), \boldsymbol{Y}(nx1)n, \boldsymbol{\beta}((p+1)x1)$. This estimator is an estimator for each row of the local matrix of parameters for all research sites with the following structure:

$$\hat{\beta} = \begin{pmatrix} \beta_0(u_1,v_1) & \beta_1(u_1,v_1) & \beta_2(u_1,v_1) & \cdots & \beta_{p(u_1,v_1)} \\ \beta_0(u_2,v_2) & \beta_1(u_2,u_2) & \beta_2(u_2,v_2) & \cdots & \beta_p(u_2,v_2) \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \beta_0(u_n,v_n) & \beta_1(u_n,v_n) & \beta_2(u_n,v_n) & \cdots & \beta_p(u_n,v_n) \end{pmatrix}$$

The parameters of each row in the matrix above can be estimated by the equation:

$$\hat{\beta}(u_i, v_i) = (X^T W(i) X)^{-1} X^T W(i) Y \tag{5}$$

Where i is the row of the matrix $\beta$ and ***W(i)*** is the n x n weighted matrix with the structure:

$$W(u_i, v_i) = diag\left[w_{i(u_i,v_i)}, w_2(u_i, v_i), \ldots., w_3(u_i, v_i)\right] \tag{6}$$

The kernel function used is the fixed gaussian kernel function which is stated as follows:

$$W_j(u_i, v_i) = exp\left[-\frac{1}{2}\left(\frac{d_{ij}}{h}\right)^2\right] \tag{7}$$

Where $d_{ij}$ is the distance between location-i and location-j and h is the bandwidth. The distance $d_{ij}$ is the Euclidean distance obtained by the following equation:

$$d_{ij} = \sqrt{\left(u_i - u_j\right)^2 + \left(v_i - v_j\right)^2}$$

In this case (u,v) is the coordinates of the location. The bandwidth value is determined by the Cross Validation (CV) method below:

$$CV(h) = \sum_{i-1}^{n} (y_i - \hat{y}_{\neq 1}(h))^2 \tag{8}$$

Where $\hat{y}_{\neq i}(h)$ is the value of the estimator where the observations at the location are omitted from the estimating process. To get the optimal value of bandwidth (h), it is obtained from h which produces a minimum CV value.

The hypothesis testing of the Geographically Weight Regression (GWR) model is carried out using the following hypotheses:
$H_0$ : $\beta$k $(ui,vi)$ = $\beta$k, k =1,2, …, p (there is no influence of geographical factors on the model)
$H_0$ : There is at least one $\beta$k $(ui,vi)$ associated with the location $(ui,vi)$ (there is an influence of geographic factors on the model). The F test statistics for the significance of the GWR model are:

$$F = \frac{(JKG_{OLS} - JKG_{GWR}) / df_1}{JKG_{GWR} / df_2} \quad (9)$$

where $d_{f1} = n - p - 1$ and $d_{f2} = n\text{-}2tr\,(S)+tr\,(S'S)$

$H_0$ is rejected, if the value of $F_{count}$ is greater than $F_{tabel}\,(\alpha, d_{f1}, d_{f2})$ or the GWR model has a goodness of fit that is better than the global regression model. The value of $F_{table}$ will follow the distribution of F with degrees of freedom $d_{f1}$ dan $d_{f2}$.

## 3. Research Methodology

The data used in this study are those obtained from field observations in 2021. The research areas are villages in the Galang sub-district which have tower footprints and villages bordering the village. The variables used in this study are as follows:

Table 1. Operational of Variable

| **Variable** | **Justufication** | **Unit** |
|---|---|---|
| Y: Nilai_Lahan | Land value | Rupiah/m² |
| $X_1$: J_L Jalan | Land distance to road access | meter |
| $X_2$: J_L Transport | Land distance to main transportation routes | meter |
| $X_3$: J_L CBD | Distance of land to trade center | meter |
| $X_4$: Elevation | Land elevation and contour | meter |

The distance between the tower footprints is the Euclidean distance from each of the latitude and longitude coordinates of the tower footprints. Response variable is land value and explanatory variable is land distance to road access, land distance to main transportation route, land distance to trade center and land contour height. The analysis steps carried out are as follows:

a. Determine the Euclidean distance between tower footprints and the distance with explanatory variables.
b. Determine the optimum window width for the Gaussian kernel function with cross validation.Menentukan estimasi parameter dan model GWR.
c. Define parameter estimates and GWR models.
d. Comparing the goodness of the GWR model with the OLS model.

## 4. Result and Discussion

Prediction modeling of land value for tower site land in Galang sub-district covers all tower site locations using OLS and GWR linear regression.

a. Ordinary Linear Regression model (OLS).

Linear regression using OLS obtained the parameter estimator of the linear regression equation model as follows:

Table 2. Estimator parameter OLS model

| Variable | Coefficient | Std. Error | t-Statistic | Probability |
|---|---|---|---|---|
| C | 8.373 | 0.788 | 10.625 | 0.000 |
| J_L Jalan (X1) | -0.026 | 0.011 | -2.349 | 0.025 |
| J_L CBD (X2) | 0.066 | 0.028 | 2.331 | 0.026 |
| J_L Transp (X3) | 0.139 | 0.062 | 2.235 | 0.032 |
| Elevation (X4) | 0.440 | 0.060 | 7.358 | 0.000 |



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Sources : Data Analysis (2022)

Based on Table 2, the OLS model for land value indication is as follows:

$$\hat{Y} = 8.373 - 0.026Ln(X_1) + 0.066Ln(X_2) + 0.139Ln(X_3) + 0.440Ln(\quad (10)$$

with a coefficient of determination (R2) of 73.7% which explains that 73.7% of the variation in response variables can be explained by explanatory variables while the remaining 26.3% is explained by other variables not included in the model. Table 2 shows that all independent variables have a p-value <0.05 so that all variables are significant. Furthermore, the prediction of the land value of the OLS model is according to Appendix 1.

According to Table 3. it is known that the land value of the OLS model is in the range of IDR. 70.000/m2 – IDR..141.000/m2. The minimum value for the indication of land value in the OLS model is IDR. 70,000/m2, lower than the observation value of IDR. 78,000/m2. For the maximum value of the land value indication is IDR. 141,000/m2 is greater than the observation value of IDR. 130,000/m2. The highest value range in the OLS model is IDR. 100,000/m2 – IDR. 120,000/m2. which includes 32 locations.

The results of the classical assumption test are normality test with Jarque-Berra for p-value (0.824051) > 0.05, multicollinearity test results for all response variables < 10, and autocorrelation test results with Breusch - Godfrey Serial Correlation LM Test, the value of Prob. The Chi-Square of Obs*R-squared is 0.7883 > 0.05. For the results of the heteroscedasticity test with Breusch-Pagan-Godfrey, the value of Prob. Chi-Square of Obs*R-squared is 0.0158 < 0.05 which indicates the occurrence of heteroscedasticity.

b. Geographically Weighted Regression model

The GWR model is used to overcome heteroscedasticity in the OLS model err (10) ance. Estimated GWR parameters as shown in Table 4 as follows:

**Table 4. Estimator parameter GWR model**

| Variable | *Estimator* $\widehat{\beta}\,(u_i, v_i)$ | | | |
|---|---|---|---|---|
| | Minimum | Maximum | Mean | Range |
| Intersep | 8.5406 | 9.0055 | 8.6952 | 0.4649 |
| J_L Jalan ($X_1$) | -0.0252 | -0.0233 | -0.0241 | 0.0019 |
| J_L CBD ($X_2$) | 0.0271 | 0.0691 | 0.0575 | 0.0419 |
| J_L Transp ($X_3$) | 0.0884 | 0.1326 | 0.1214 | 0.0443 |
| Elevation ($X_4$) | 0.3415 | 0.4539 | 0.4066 | 0.1124 |

Sources : Data Analysis (2022)

Based on Table 4, the GWR model land value predictions for Location-25 are:

$$ln\hat{Y} = 8.600 - 0.0235\, ln(X_1) + 0.0669\, ln(X_2) + 0.1316\, ln(X_3) + 0.3916\, ln(X_4) \quad (11)$$

For other locations the parameter estimates are as shown in Appendix 2.

According to Appendix 2. it is known that the land value of the GWR model is in the range of IDR. 85,000/m2 – IDR. 125,000/m2. The minimum value for the GWR model land value indication is IDR. 85,000/m2, higher than the observation value of IDR. 78,000/m2. For the maximum value of the land value indication is IDR. 125,000/m2 is lower than the observation value of IDR. 130,000/m2. The highest value range for the GWR model is IDR. 100,000/m2 – IDR. 125,000/m2, which includes 33 locations.

The predictions of the land value of the OLS model and the GWR model are compared with the observed land value as shown in Figure 1. as follows:



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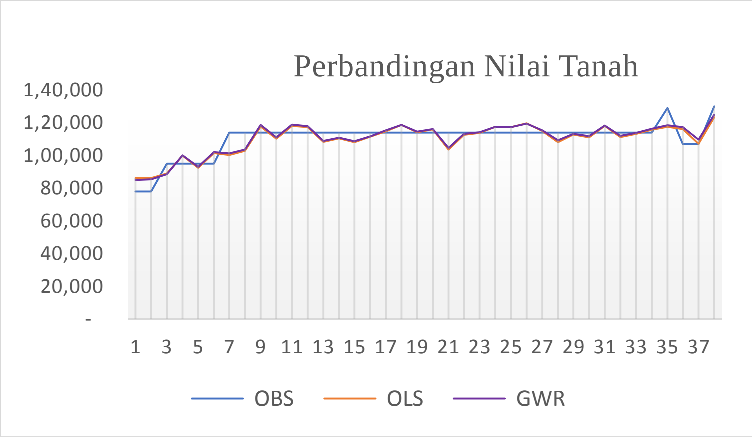


Figure 1. Comparison of indications of land value in the OLS and GWR models with Observations

Figure 1. shows that each land location has a different value that varies between the observed land value and the predicted value of the GWR model and the OLS model. The difference in land value (IDR/m2), whether the value increases or decreases, generally occurs at the same location. Furthermore, the magnitude of the values that occur at each location in the OLS and GWR models can be seen in Appendix 3.

Appendix 3. shows the land value and the difference in land values observed using the OLS and GWR models. The sign (-) indicates that the value of the observation is smaller than the value of the soil model in rupiah/m2 and vice versa. The smaller the difference in land values indicates that the model land value is getting closer to the observed value.

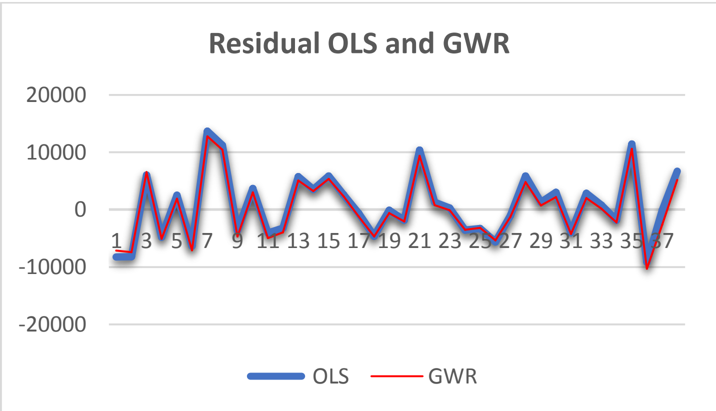


Figure 2. Difference in land value (residual) OLS and GWR

Figure 2. shows fluctuations in the difference in land values of the OLS model compared to the GWR model. The location of this land value fluctuation is generally in the same location. Overall the difference in the value of the observed land with the indication of the predicted land value of the OLS model is IDR. 20,020/m2, while the GWR model is IDR. 5.562/m2. Based on these data, it can be said that the prediction of the GWR model land value indication is closer to the land value from field observations.

In the GWR model, each location has its own parameter estimator which gives weight to the predictor variables in each land location. Based on the results of the partial test, the influence of the predictor variables is as follows:

The predictor variable of land distance to the nearest road. The parameter estimation in Table 4. shows the value of the parameter estimator of the GWR model $\beta_1$ is in the range of -0.031758 to -0.006765. The negative value in the parameter $\beta_1$ indicates a negative relationship between the distance from the land to the road ($X_1$) and the value of the land. The negative relationship of this predictor variable occurs in all tower sites. This relationship states that the closer the land location is to the road, the higher the value will be and will continue to decrease with the increase in the



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distance from the land to the road. The distance from the land to the road is relatively close and is still within the unitary area so that it does not affect the diversity of land locations.

The predictor variable of land distance to the Central Business District (CBD). In this study, what is meant by CBD is the economic center of the community in Galang sub-district. The estimator value for the parameter $\beta_2$ is in the range of 0.027097 to 0.069053. A positive value in the parameter $\beta_2$ indicates a positive relationship between the distance of land to the CBD ($X_2$) and the value of the land. This can be explained by using the graph of the bid-rent function and land use in the CDB (Yates., M. 1990 in Pontoh and Kustiwan, 2008) in Appendix 1. The graph states that the rent value of land that is used as agricultural land is relatively constant and not affected by its distance to the CBD. The land for this tower site is generally located in an area that is functioned as a garden and its location is within the plantation land area. The proximity of the land to the CBD does not necessarily lead to an increase in land prices in that location.

The predictor variable of land distance to the main transportation route. The estimator value on the variable distance of land to the main transportation route $X_3$ is in the range of 0.088369 to 0.132642. A positive value in the parameter $\beta_3$ indicates a positive relationship between the distance of the land to the main transportation route ($X_3$) and the value of the land. As the influence of the CBD variable on the land value of the tower footprint, the influence of the variable distance of land to the main transportation route on the value of the tower footprint land can be explained by the land function and the location of the tower footprint. The initial function of the tower site land is a garden and is located in a plantation area, so that the proximity of the tower footprint land to the main transportation route does not necessarily increase the value of the land. Although the tower footprint land has been converted into electricity infrastructure land, this land is only a small parcel located within a much larger area of land and functions as a plantation.

Predictor variable Elevation/topography of land. The estimator value of parameter $\beta_4$ is in the range of 0.341459 to 0.453859. A positive value for the parameter $\beta_4$ indicates a positive relationship between elevation ($X_4$) and the soil value. This positive relationship occurs in all tower sites. This relationship states that the greater the elevation of the land ($X_4$), the higher the value.

The existence of the same predictor variable parameter estimator with a different value from one location to another indicates that there is diversity at that location. This diversity can be sourced from population density, job diversity, education level, regional conditions and others.

Table 7. Evaluation of land value prediction models

| Model | AIC | R-Square | Selisih Nilai Observasi |
|---|---|---|---|
| OLS | -102,80 | 73,74% | Rp. 25.020/$m^2$ |
| GWR | -104,63 | 75,98% | Rp. 5.562/$m^2$ |

Table 7. is an evaluation of the OLS and GWR models used with the criteria of AIC, R-square and the difference between the predictions of the model's land value and the observed values. The evaluation results show that the performance of the GWR model is better than the OLS model.

## 5. Conclusion

The parameter coefficients for each location of the tower area are different which indicates the presence of spatial heterogeneity so that the analysis with GWR is used. The results of the prediction of the land value of the 150 kV TL tower site GI Galang – GI Negeri Dolok in Galang sub-district using the GWR model is more accurate and significant than the OLS model. This is based on the value of AIC, R-square and the difference in the value of the observed land with the GWR model which is better than the OLS model.

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**Appendix 1.** OLS land value prediction model

| Lokasi | OBS (Rp/m2) | OLS (Rp/m2) | GWR (Rp/m2) | Selisih OBS – OLS (Rp/m2) | Selisih OBS – GWR (Rp/m2) |
|---|---|---|---|---|---|
| 1 | 78,000 | 86,236 | 85,128 | -8236 | -7128 |
| 2 | 78,000 | 86,161 | 85,404 | -8161 | -7404 |
| 3 | 95,000 | 88,932 | 88,459 | 6068 | 6541 |
| 4 | 95,000 | 99,800 | 100,029 | -4800 | -5029 |
| 5 | 95,000 | 92,489 | 93,109 | 2511 | 1891 |
| 6 | 95,000 | 101,361 | 102,046 | -6361 | -7046 |
| 7 | 114,000 | 100,342 | 101,211 | 13658 | 12789 |
| 8 | 114,000 | 102,763 | 103,552 | 11237 | 10448 |
| 9 | 114,000 | 117,651 | 118,645 | -3651 | -4645 |
| 10 | 114,000 | 110,273 | 110,944 | 3727 | 3056 |
| 11 | 114,000 | 118,023 | 118,921 | -4023 | -4921 |
| 12 | 114,000 | 117,204 | 117,914 | -3204 | -3914 |
| 13 | 114,000 | 108,222 | 108,931 | 5778 | 5069 |
| 14 | 114,000 | 110,468 | 110,725 | 3532 | 3275 |
| 15 | 114,000 | 108,100 | 108,644 | 5900 | 5356 |
| 16 | 114,000 | 111,393 | 111,680 | 2607 | 2320 |
| 17 | 114,000 | 114,659 | 115,231 | -659 | -1231 |
| 18 | 114,000 | 118,594 | 118,637 | -4594 | -4637 |
| 19 | 114,000 | 114,084 | 114,589 | -84 | -589 |
| 20 | 114,000 | 115,829 | 116,066 | -1829 | -2066 |
| 21 | 114,000 | 103,586 | 104,627 | 10414 | 9373 |
| 22 | 114,000 | 112,678 | 113,205 | 1322 | 795 |
| 23 | 114,000 | 113,725 | 114,071 | 275 | -71 |
| 24 | 114,000 | 117,535 | 117,491 | -3535 | -3491 |
| 25 | 114,000 | 117,290 | 117,183 | -3290 | -3183 |
| 26 | 114,000 | 119,635 | 119,327 | -5635 | -5327 |
| 27 | 114,000 | 114,978 | 115,220 | -978 | -1220 |
| 28 | 114,000 | 108,108 | 109,198 | 5892 | 4802 |
| 29 | 114,000 | 112,679 | 113,236 | 1321 | 764 |
| 30 | 114,000 | 110,960 | 111,783 | 3040 | 2217 |
| 31 | 114,000 | 118,010 | 118,205 | -4010 | -4205 |
| 32 | 114,000 | 111,152 | 111,994 | 2848 | 2006 |
| 33 | 114,000 | 113,219 | 113,796 | 781 | 204 |
| 34 | 114,000 | 115,801 | 116,200 | -1801 | -2200 |
| 35 | 129,000 | 117,562 | 118,374 | 11438 | 10626 |
| 36 | 107,000 | 116,145 | 117,273 | -9145 | -10273 |
| 37 | 107,000 | 107,062 | 109,599 | -62 | -2599 |
| 38 | 130,000 | 123,271 | 124,794 | 6729 | 5206 |

**Appendix 2.** Land value parameter estimation of GWR model

| Lokasi | Desa | x_coord | y_coord | $\beta_0$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | $\beta_4$ | $y_{OBS}$ | $\hat{y}_{GWR}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Batu Lokong | 98.8675 | 3.44883 | 9.0055 | -0.0252 | 0.0271 | 0.0884 | 0.4539 | 78,000 | 85,128 |
| 2 | Pisang Pala | 98.8702 | 3.44884 | 8.9788 | -0.0252 | 0.0287 | 0.0905 | 0.4533 | 78,000 | 85,404 |
| 3 | Pisang Pala | 98.8711 | 3.44627 | 8.9217 | -0.0251 | 0.0319 | 0.0953 | 0.4519 | 95,000 | 88,459 |
| 4 | Pisang Pala | 98.8704 | 3.44319 | 8.8737 | -0.0249 | 0.0346 | 0.0993 | 0.4505 | 95,000 | 100,029 |
| 5 | Pisang Pala | 98.8701 | 3.43977 | 8.8216 | -0.0246 | 0.0377 | 0.1037 | 0.4487 | 95,000 | 93,109 |
| 6 | Kp. Kelapa Satu | 98.8695 | 3.43646 | 8.7774 | -0.0244 | 0.0404 | 0.1075 | 0.4469 | 95,000 | 102,046 |
| 7 | Kp. Kelapa Satu | 98.8719 | 3.43448 | 8.7361 | -0.0243 | 0.0431 | 0.1111 | 0.4449 | 114,000 | 101,211 |
| 8 | Kp. Kelapa Satu | 98.8734 | 3.43284 | 8.7074 | -0.0242 | 0.0450 | 0.1136 | 0.4433 | 114,000 | 103,552 |
| 9 | Paya Kuda | 98.8752 | 3.43098 | 8.6780 | -0.0241 | 0.0470 | 0.1162 | 0.4414 | 114,000 | 118,645 |
| 10 | Paya Kuda | 98.8779 | 3.42822 | 8.6398 | -0.0240 | 0.0499 | 0.1198 | 0.4384 | 114,000 | 110,944 |
| 11 | Paya Kuda | 98.8789 | 3.42634 | 8.6209 | -0.0239 | 0.0514 | 0.1216 | 0.4366 | 114,000 | 118,921 |
| 12 | Sungei Putih | 98.8804 | 3.42358 | 8.5968 | -0.0238 | 0.0534 | 0.1240 | 0.4338 | 114,000 | 117,914 |
| 13 | Sungei Putih | 98.8819 | 3.42083 | 8.5772 | -0.0237 | 0.0553 | 0.1261 | 0.4308 | 114,000 | 108,931 |
| 14 | Sungei Putih | 98.8834 | 3.41802 | 8.5619 | -0.0236 | 0.0571 | 0.1279 | 0.4277 | 114,000 | 110,725 |
| 15 | Sungei Putih | 98.8838 | 3.41607 | 8.5546 | -0.0235 | 0.0580 | 0.1288 | 0.4257 | 114,000 | 108,644 |
| 16 | Sungei Putih | 98.8850 | 3.41420 | 8.5482 | -0.0235 | 0.0591 | 0.1297 | 0.4234 | 114,000 | 111,680 |
| 17 | Sungei Putih | 98.8865 | 3.41192 | 8.5429 | -0.0234 | 0.0603 | 0.1307 | 0.4205 | 114,000 | 115,231 |
| 18 | Sungei Putih | 98.8878 | 3.40986 | 8.5406 | -0.0234 | 0.0613 | 0.1314 | 0.4178 | 114,000 | 118,637 |
| 19 | Sungei Putih | 98.8893 | 3.40731 | 8.5406 | -0.0234 | 0.0624 | 0.1320 | 0.4144 | 114,000 | 114,589 |
| 20 | Sungei Putih | 98.8904 | 3.40471 | 8.5434 | -0.0233 | 0.0633 | 0.1324 | 0.4110 | 114,000 | 116,066 |
| 21 | Galang Barat | 98.8915 | 3.40272 | 8.5476 | -0.0233 | 0.0640 | 0.1326 | 0.4083 | 114,000 | 104,627 |
| 22 | Galang Barat | 98.8933 | 3.39865 | 8.5604 | -0.0234 | 0.0652 | 0.1326 | 0.4027 | 114,000 | 113,205 |
| 23 | Galang Barat | 98.8946 | 3.39618 | 8.5715 | -0.0234 | 0.0658 | 0.1325 | 0.3991 | 114,000 | 114,071 |
| 24 | Galang Barat | 98.8955 | 3.3942 | 8.5816 | -0.0234 | 0.0663 | 0.1322 | 0.3962 | 114,000 | 117,491 |



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**Appendix 2. Continued**

| Lokasi | Desa | x_coord | y_coord | $\beta_0$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | $\beta_4$ | $y_{OBS}$ | $\hat{y}_{GWR}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Bandar Kwala | 98.8972 | 3.39122 | 8.6001 | -0.0235 | 0.0669 | 0.1316 | 0.3916 | 114,000 | 117,183 |
| 26 | Bandar Kwala | 98.8971 | 3.38834 | 8.6157 | -0.0235 | 0.0673 | 0.1311 | 0.3880 | 114,000 | 119,327 |
| 22 | Galang Barat | 98.8933 | 3.39865 | 8.5604 | -0.0234 | 0.0652 | 0.1326 | 0.4027 | 114,000 | 113,205 |
| 23 | Galang Barat | 98.8946 | 3.39618 | 8.5715 | -0.0234 | 0.0658 | 0.1325 | 0.3991 | 114,000 | 114,071 |
| 24 | Galang Barat | 98.8955 | 3.39420 | 8.5816 | -0.0234 | 0.0663 | 0.1322 | 0.3962 | 114,000 | 117,491 |
| 25 | Bandar Kwala | 98.8972 | 3.39122 | 8.6001 | -0.0235 | 0.0669 | 0.1316 | 0.3916 | 114,000 | 117,183 |
| 26 | Bandar Kwala | 98.8971 | 3.38834 | 8.6157 | -0.0235 | 0.0673 | 0.1311 | 0.3880 | 114,000 | 119,327 |
| 27 | Bandar Kwala | 98.8974 | 3.38519 | 8.6361 | -0.0236 | 0.0677 | 0.1303 | 0.3838 | 114,000 | 115,220 |
| 28 | Bandar Kwala | 98.8977 | 3.38265 | 8.6538 | -0.0237 | 0.0680 | 0.1295 | 0.3804 | 114,000 | 109,198 |
| 29 | Bandar Kwala | 98.898 | 3.37874 | 8.6834 | -0.0238 | 0.0683 | 0.1282 | 0.3750 | 114,000 | 113,236 |
| 30 | Bandar Kwala | 98.9008 | 3.37734 | 8.7050 | -0.0239 | 0.0686 | 0.1272 | 0.3713 | 114,000 | 111,783 |
| 31 | Bandar Kwala | 98.9030 | 3.37614 | 8.7241 | -0.0241 | 0.0687 | 0.1262 | 0.3683 | 114,000 | 118,205 |
| 32 | Baru Titi Besi | 98.9063 | 3.37454 | 8.7517 | -0.0243 | 0.0689 | 0.1249 | 0.3640 | 114,000 | 111,994 |
| 33 | Kp. Paku | 98.9073 | 3.37211 | 8.7781 | -0.0244 | 0.0690 | 0.1235 | 0.3599 | 114,000 | 113,796 |
| 34 | Kp. Paku | 98.9082 | 3.37052 | 8.7969 | -0.0245 | 0.0690 | 0.1226 | 0.3571 | 114,000 | 116,200 |
| 35 | Kp. Paku | 98.9094 | 3.36840 | 8.8231 | -0.0247 | 0.0690 | 0.1212 | 0.3533 | 129,000 | 118,374 |
| 36 | Kp. Paku | 98.9106 | 3.36664 | 8.8463 | -0.0248 | 0.0691 | 0.1200 | 0.3500 | 107,000 | 117,273 |
| 37 | Kp. Paku | 98.9114 | 3.36488 | 8.8679 | -0.0250 | 0.0690 | 0.1189 | 0.3470 | 107,000 | 109,599 |
| 38 | Kp. Paku | 98.9130 | 3.36175 | 8.9087 | -0.0252 | 0.0690 | 0.1167 | 0.3415 | 130,000 | 124,794 |



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**Appendix 3.** Difference in land values

| Lokasi | OBS (Rp/m2) | OLS (Rp/m2) | GWR (Rp/m2) | Selisih OBS – OLS (Rp/m2) | Selisih OBS – GWR (Rp/m2) |
|---|---|---|---|---|---|
| 1 | 78,000 | 86,236 | 85,128 | -8236 | -7128 |
| 2 | 78,000 | 86,161 | 85,404 | -8161 | -7404 |
| 3 | 95,000 | 88,932 | 88,459 | 6068 | 6541 |
| 4 | 95,000 | 99,800 | 100,029 | -4800 | -5029 |
| 5 | 95,000 | 92,489 | 93,109 | 2511 | 1891 |
| 6 | 95,000 | 101,361 | 102,046 | -6361 | -7046 |
| 7 | 114,000 | 100,342 | 101,211 | 13658 | 12789 |
| 8 | 114,000 | 102,763 | 103,552 | 11237 | 10448 |
| 9 | 114,000 | 117,651 | 118,645 | -3651 | -4645 |
| 10 | 114,000 | 110,273 | 110,944 | 3727 | 3056 |
| 11 | 114,000 | 118,023 | 118,921 | -4023 | -4921 |
| 12 | 114,000 | 117,204 | 117,914 | -3204 | -3914 |
| 13 | 114,000 | 108,222 | 108,931 | 5778 | 5069 |
| 14 | 114,000 | 110,468 | 110,725 | 3532 | 3275 |
| 15 | 114,000 | 108,100 | 108,644 | 5900 | 5356 |
| 16 | 114,000 | 111,393 | 111,680 | 2607 | 2320 |
| 17 | 114,000 | 114,659 | 115,231 | -659 | -1231 |
| 18 | 114,000 | 118,594 | 118,637 | -4594 | -4637 |
| 19 | 114,000 | 114,084 | 114,589 | -84 | -589 |
| 20 | 114,000 | 115,829 | 116,066 | -1829 | -2066 |
| 21 | 114,000 | 103,586 | 104,627 | 10414 | 9373 |
| 22 | 114,000 | 112,678 | 113,205 | 1322 | 795 |
| 23 | 114,000 | 113,725 | 114,071 | 275 | -71 |
| 24 | 114,000 | 117,535 | 117,491 | -3535 | -3491 |
| 25 | 114,000 | 117,290 | 117,183 | -3290 | -3183 |
| 26 | 114,000 | 119,635 | 119,327 | -5635 | -5327 |
| 27 | 114,000 | 114,978 | 115,220 | -978 | -1220 |
| 28 | 114,000 | 108,108 | 109,198 | 5892 | 4802 |
| 29 | 114,000 | 112,679 | 113,236 | 1321 | 764 |
| 30 | 114,000 | 110,960 | 111,783 | 3040 | 2217 |
| 31 | 114,000 | 118,010 | 118,205 | -4010 | -4205 |
| 32 | 114,000 | 111,152 | 111,994 | 2848 | 2006 |
| 33 | 114,000 | 113,219 | 113,796 | 781 | 204 |


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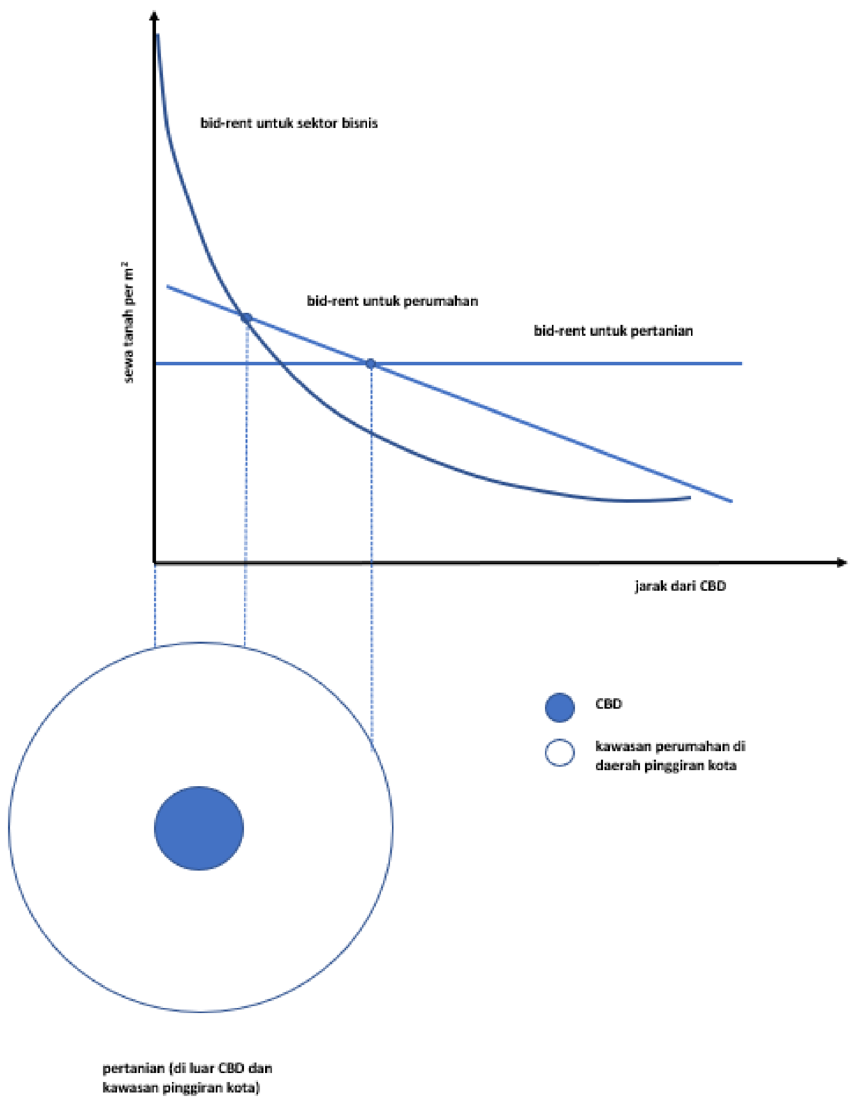
**Appendix 3.** Continued

| Lokasi | OBS (Rp/m2) | OLS (Rp/m2) | GWR (Rp/m2) | Selisih OBS – OLS (Rp/m2) | Selisih OBS – GWR (Rp/m2) |
|---|---|---|---|---|---|
| 34 | 114,000 | 115,801 | 116,200 | -1801 | -2200 |
| 35 | 129,000 | 117,562 | 118,374 | 11438 | 10626 |
| 36 | 107,000 | 116,145 | 117,273 | -9145 | -10273 |
| 37 | 107,000 | 107,062 | 109,599 | -62 | -2599 |
| 38 | 130,000 | 123,271 | 124,794 | 6729 | 5206 |

**Appendix 4.** Graph of bid-rent and land use functions in the CBD Source: Yates, M., (1999) in Pontoh & Iwan (2008)



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