GIS Mapping Based on Spatial-Temporal Model Estimation Affecting COVID-19 Outbreak in Kalimantan

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ABSTRACT
Innovation of Spatio-temporal analysis specifically for the geographically Weighted Panel Regression model with the development of geographic-weighted functions for spatial and temporal interactions. Map the GIS based on Spatio-temporal model estimation for the factors that may provide influence on the increase in the number of positive cases of COVID-19 in Kalimantan. Observation data consisted of 56 which was based on the Regency/City scale in Kalimantan. The variables used in this study were COVID-19 cases, number of doctors, number of hospitals, number of health care centers, number of tuberculosis cases, percentage of the elderly population, population density, percentage of the lower class population, and gross regional domestic income as regional economic indicators. COVID-19 data used in this study were the data from 2020 to August 10, 2021. The study utilized Spatio-temporal analysis with the Geographically Weighted Panel Regression model by involving the development geographic weighting of Gaussian, Bisquare, and Tricube kernel functions. The GWPR model is able to provide better estimator results than the Geographically Weighted Regression (GWR) model because it considers location and time aspects simultaneously. The results of this study, the GWPR model with Improve geographic weighting of the Bisquare kernel function was considered the most acceptable method. The model criteria were based on the coefficient of determination and RMSE. The results of the significance test of the GWPR model parameters on 56 Regency/City data in Kalimantan had succeeded in mapping the area into 24 categories based on the significant variables of each region.

Keywords: *GIS Mapping, Spatio-temporal, Geographically Weighted Panel Regression, COVID-19 Outbreak, Applied Geography.*

1. INTRODUCTION

Kalimantan continues to face an increasing number of positive cases of COVID-19. Consequently, this study was intended to identify the contributing factors of positive cases of COVID-19 and examine the influence provided by these factors, which was visualized in GIS mapping. This study was focused on the Geographically Weighted Panel Regression model [1], [2], [3], [4], [5] which would be utilized to measure data on the number of positive COVID-19 cases and contributing variables. Geographically Weighted Panel Regression study is defined as one of spatial and Spatio-temporal analysis [6], [7], [8]. Researchers have widely used the Spatio-temporal analysis model: Geographically Weighted Panel Regression to analyze COVID-19 data in various countries [9], [10].

Research Objectives to determine GIS mapping based on factors that highly influence the increase in the number of COVID-19 in Kalimantan employing Spatio-temporal analysis: Geographically Weighted Panel Regression (GWPR). The results of the study obtained The comparison of the global regression model, the GWR and GWPR models shows that the GWPR model is a better model to see the influence of predictor variables with an R2 value that is greater than the Global and GWR models. The results of this study may be capable of being used to provide information related to the level of influence of these variables and GIS mapping according to the influence provided. Therefore, readers may be able to identify the highly influential factors that need to be improved, to reduce the number of COVID-19 cases in the Kalimantan region. The predictor variables involved in this study were population density, Gross Regional Domestic Product, number of hospitals, number of villages/sub-districts with health care centers and number of tuberculosis cases. The study included the use of COVID-19 data for the period of 2020 to August 2021. The contribution of research can provide information related to how high and low the influence of these variables is and GIS mapping based on the influence of variables. So that readers can find out what factors are very influential and need improvement to reduce the number of COVID-19 cases in the Kalimantan area..

2. MATERIAL AND METHOD

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2.1. Spatio-temporal with Geographically Weighted Panel Regression (GWPR)

The GWPR model is referred to as a spatial regression model, which aims to simultaneously measure the effects of spatial and time. The GWPR model is also commonly regarded as the development model of geo-weighted panel regression. The GWR equation may be combined with the FEM panel regression equation by means of within estimator at the i-th observation and t-time as formulated in the following Equation (1) [8].

$$y^{8}_{it=}\ \beta_0\left(u_{it\,,}\ v_{it}\right)+\beta_1\left(u_{it\,,}\ v_{it}\right)x^*_{it1}+\beta_2\left(u_{it\,,}\ v_{it}\right)x^*_{it2}$$
$$+\cdots+\beta_1\left(u_{it\,,}\ v_{it}\right)x^*_{itp}\varepsilon^*_{it};\ i=1{,}2..\pi, t=1{,}2\ldots T \quad (1)$$

Referring to the components in Equation (1), variable y^*_{it} is referred to as the value of the response variable at the i-th observation and t-time, variable x^*_{itk} is the value of the k-th predictor variable at the i-th observation and t-time, parameter β_0 is the regression constant of the GWPR model from the Equation formed at the i-th observation and the t-time, parameter β_k is the regression coefficient of the GWPR model on the k-th predictor variable of the k-th demeaned variable at the i-th observation and t-time, (u_{it}, v_{it}) coordinate is the coordinate of the observation location at the i-th observation and t-time, and error ε_{it} is a random error that is assumed to be independent, identical and follows a normal distribution with zero mean and constant variance.

Parameter estimation of the GWPR model may be conducted by means of the Weighted Least Square (WLS) approach, by providing different weighting elements for each location and time of observation. In addition, wijt(uit,vit) wijtuit,vit $w_{ijt}(u_{it}, v_{it})$ is declared as the spatial weight provided by the j-th location observations for the GWR model at the i-th location and t-time. The estimator for the GWPR model [15] can be formulated according to Equation (2).

$$\hat{\beta}\left(u_{it\,,}\ v_{it}\right)=\left(x^*_{iTW}\left(u_{it\,,}v_{it,}\right)X^*\right)^{-1}-\ x^{*T}W\left(u_{it\,,}v_{it,}\right)y^* \quad (2)$$

Where

$$X^{*T}_{it}=\begin{bmatrix}1 & x^*_{i11} & x^*_{i12}\ldots x^*_{i1p}\\ 1 & x^*_{i11} & x^*_{i22}\ldots x^*_{i2p}\\ \ldots & \ldots & \ldots\\ 1 & x^*_{iT1} & x^*_{iT2}\ldots x^*_{i2p}\end{bmatrix}$$

$ix^{*T}_{it}=s$ the i-th sequence of each t-th unit of the $\boldsymbol{X}^*$ matrix. $W\left(u_{it\,,}v_{it,}\right)$is the geographic weighting matrix, which may be formulated as

$$W\left(u_{it\,,}v_{it,}\right)$$
$$=diag[w_{i11}, w_{i21}, \ldots .w_{in1}, w_{il2}, w_{i1T}, w_{i2T}, \ldots w_{inT}]$$

2.2. Data and Data Sources

The data used in this study consisted of the response variable (y), predictor variable (X), and the coordinates of the location of each Regency/City in Kalimantan. Data related to the number of positive cases of COVID-19 were successfully obtained from the official website:

(https://covid19.kaltimprov.go.id/, https://coronainfo.kaltaraprov.go.id/; https://corona.kalselprov.go.id/, https://corona.kalteng.go.id/, https://corona.kalbarprov.go.id/sebaran).

The Predictor Variables which consisted of the number of doctors (x_1), the number of hospitals (x_2), the number of villages/sub-districts with Health Care Centers (x_3) and the number of tuberculosis cases (x_4) were successfully obtained from the Provincial Health Department in Kalimantan: Health Department of East Kalimantan Province, 2021; Health Department of North Kalimantan Province, 2021; Health Department of South Kalimantan Province [14], Health Department of Central Kalimantan Province [11], Health Department of West Kalimantan Province [15], Health Department of East Kalimantan [12] and North Kalimantan [13]. Moreover, the Predictor Variables which comprised of the percentage of elderly population the number of tuberculosis cases (x_5), the percentage of population density the number of tuberculosis cases (x_6), the percentage of lower class population the number of tuberculosis cases (x_7), Gross Regional Domestic Product (GRDP) the number of tuberculosis cases (x_8) were respectively derived from the National Bureau of Statistic (locally known as BPS) at the provincial level, specifically BPS of East Kalimantan Province in 2020 and 2021 [18], [19]; BPS of North Kalimantan Province in 2020 and 2021 [20], [21]; BPS of South Kalimantan Province in 2020 and 2021 [22], [23]; BPS of Central Kalimantan Province in 2020 and 2021 [16], [17], and BPS of West Kalimantan Province in 2020 and 2021[24], [25].

2.3. Data Analysis Technique

Referring to the objectives of this study, the researchers were successfully conducted several stages of data analysis to map the GIS Based on Geographically Weighted Panel Regression Model For Cumulative COVID-19 Data in Kalimantan.

1. Conducting descriptive statistical analysis of the study data, specifically minimum value, maximum value, mean $\bar{x}$, and standard deviation s on variable data and designing descriptive maps assisted by R 3.6.1 and ArcView GIS 3.3 softwares.
2. Conducting an exploration of the distribution of response variables and predictor variables in the period of 2020-2021 by utilizing spatial distribution mapping.
3. Analyzing the GWPR model by using Octave 5.2.0 software
4. Estimating the Geographically Weighted Panel Regression model
5. Mapping the spread of COVID-19 according to the Geographically Weighted Panel Regression model estimation.

3. RESULTS AND DISCUSSION

In this section, the researchers will initially describe the information related to the spatial distribution mapping, the data description of the number of positive COVID-19 cases along with the contributing variables. Subsequently, the researchers will focus on the analysis of GWPR model parameter estimator and the Mapping of GIS Based on GWPR Model Estimation For Cumulative COVID-19 Data in East Kalimantan.

3.1. Descriptive Statistics and Spatial Distribution Mapping

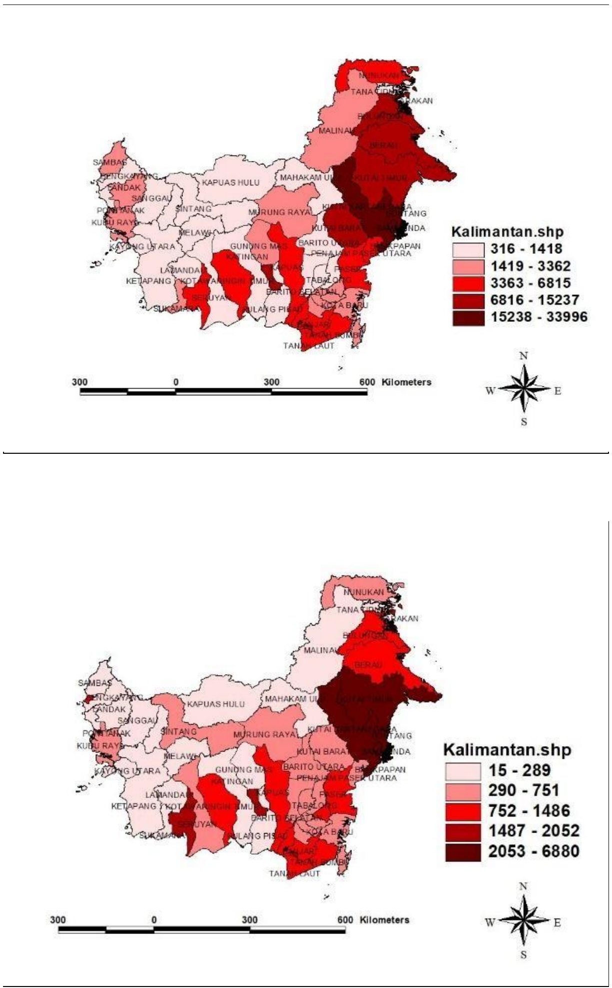


Figure 1 Distribution map of the number of positive covid-19 cases in kalimantan

The mapping of the spatial distribution of observational data on the number of positive COVID-19 cases in 2020-2021 is presented in Figure 1. Having regard to Figure 1, the number of positive cases of COVID-19 in Kalimantan was classified by researchers into 5 categories as shown in Table 1.

The number of positive cases for the coronavirus is continuing to rise rapidly throughout the years. This issue is indicated by an increase in the numbers listed in the figure description. The highest number of positive cases was found in Kutai Kartanegara Regency, Balikpapan City, and Samarinda City, respectively. The description of the independent variable data consisted of mean, maximum value, minimum value, and standard deviation. Furthermore, descriptive statistics were successfully calculated by means of R 3.6.1 software, and the description of the independent variable data can be seen in Table 2.

Table 1. Classification of Total Positive Cases of COVID-19 in Kalimantan.

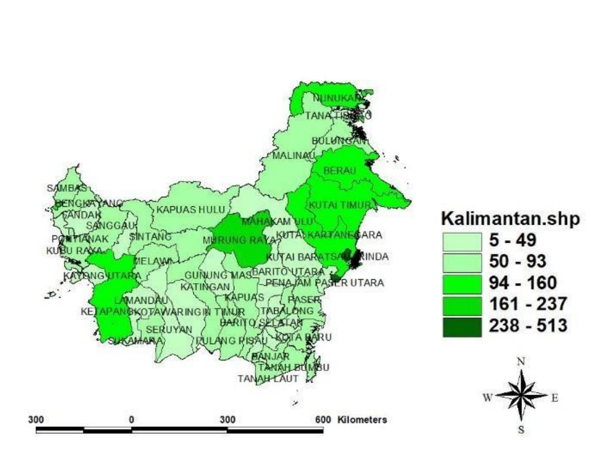
In 2020		In 2021	
Total Positive Cases of COVID-19	**Regency/City**	**Total Positive Cases of COVID-19**	**Regency/City**
15 – 289 People	Mahakam Ulu, Malinau, Tana Tidung, Sukamara, Lamandau, Katingan, Pulang Pisau, Gunung Mas, Sambas, Bengkayang, Landak, Mempawah, Sanggau, Ketapang, Kapuas Hulu, Sekadau, Melawi, and North Kayong	316 – 1418 People	Mahakam Ulu, Malinau, Tana Tidung, South Barito, North Barito, Lamandau, Katingan, Pulang Pisau, East Barito, Tabalong, Bengkayang, Mempawah, Sanggau, Ketapang, Sintang, Kapuas Hulu, Sekadau, Melawi, North Kayong, and Singkawang
290 – 751 People	West Kutai, North Penajam Paser, Nunukan, South Barito, North Barito, Seruyan, East Barito, Murung Raya, Kotabaru, Tapin, South Hulu Sungai, Central Hulu Sungai, North Hulu Sungai, Tabalong, Sintang, and Kubu Raya	1419 – 3362 People	Malinau, Sukamara, Gunung Mas, Murung Raya, Kotabaru, Tapin, South Hulu Sungai, Central Hulu Sunga, North Hulu Sungai, Balangan, Sambas, Landak, Kubu Raya, and Pontianak
752 – 1486 People	Paser, Berau, Bulungan, East Kotawaringin, Kapuas, Tanah Laut, Banjar, Barito Kuala, Tanah Bumbu, Balangan, and Singkawang	3363 – 6815 People	Paser, North Penajam Paser, Nunukan, West Kotawaringin, East Kotawaringin, Kapuas, Tanah Laut, Banjar, Barito Kuala, and Tanah Bumbu
1487 – 2052 People	Bontang, Tarakan, West Kotawaringin, Palangka Raya, Banjar Baru, and Pontianak	6816 – 15237 People	West Kutai, East Kutai, Berau, Bontang, Bulungan, Tarakan, Palangka Raya, Banjarmasin, and Banjar Baru
2053 – 6880 People	Kutai Kartanegara, East Kutai, Balikpapan, Samarinda, and Banjarmasin	15238 – 33996 People	Kutai Kartanegara, Balikpapan, and Samarinda

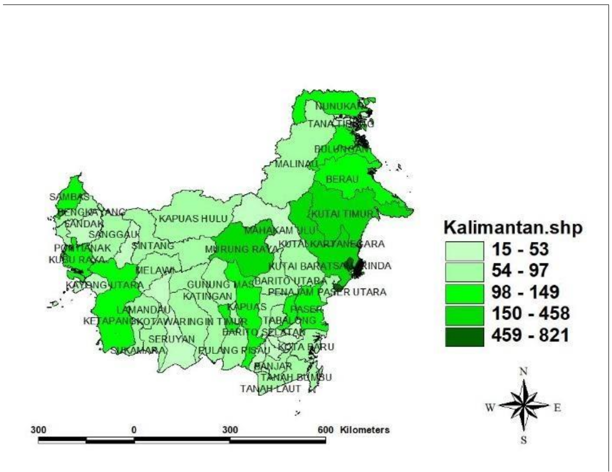
Table 2 indicates that the average number of doctors was amounted to 107,900 doctors with a standard deviation of 129,654. The highest number of doctors was amounted to 821, and the lowest was amounted to 5. In addition, the average number of hospitals was amounted to 3,411 units with a standard deviation of 3,389. The highest number of hospitals was 20 units, and the lowest was amounted to 1 unit. The average number of villages/sub-districts with health care centers

Table 2. Descriptive statistics of predictor variables

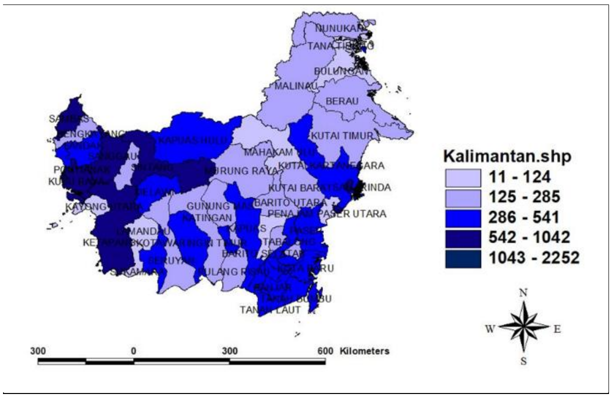
Variable	**Iean**	**ximum**	**imum**	**Standard Deviation**
The number of doctors (x1)	107,900	821,000	5,000	129,654
The number of hospitals x2	3,411	20,000	1,000	3,389
The number of hospitals x3	34,470	212,000	5,000	40,111
The number of villages/sub-districts with Health Care Centers x4	440,000	2708,000	11,000	407,731
The number of Tuberculosis cases x5	10,261	59,180	1,560	10,849
The percentage of elderly population x6	2,300	972,0	000	03,424
The percentage of population density x7	,027	2,380	420	2,332
GRDP x8	38,000	160,000	3,000	461,650

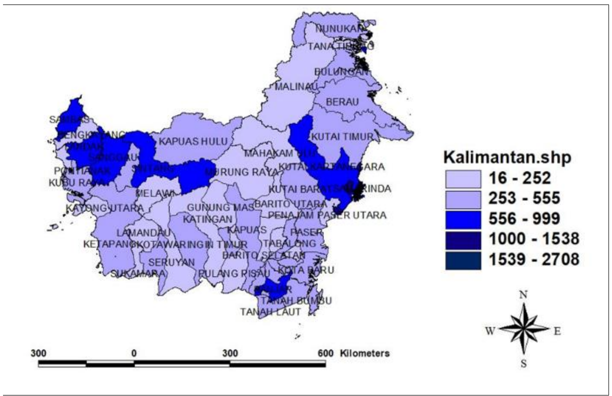
was amounted to 34,470 units with a standard deviation of 40,111. Moreover, the highest number of health care centers was in the amount of 212 units and the lowest was 5 units. The average number of tuberculosis cases was in the amount of 440 cases with a standard deviation of 407,731. The highest number of tuberculosis cases was amounted to 2,708 cases and the lowest was amounted to 11 cases. Furthermore, the percentage of elderly population was found to be 10.261% with a standard deviation of 10,849. The highest percentage of the elderly population was amounted to 59.180% and the lowest was 1.560%. Additionally, the average population density was amounted to 402,300 people/Km2 with a standard deviation of 1403,424. The highest population density was found to be 8972.0 people/Km2, and the lowest was amounted to 1 person/Km2. The average percentage of the lower class population was 6.027% with a standard deviation of 2.332. The highest percentage of the lower class population was amounted to 12.380% and the lowest was amounted to 2.420%. The average gross regional domestic income was in the amount of 16,238 billion rupiah with a standard deviation of 22461,650. The highest gross regional domestic income was amounted to 16,238 billion rupiah and the lowest was found to be 1,763 billion rupiah. Spatial distribution mapping is presented in Figure 2.



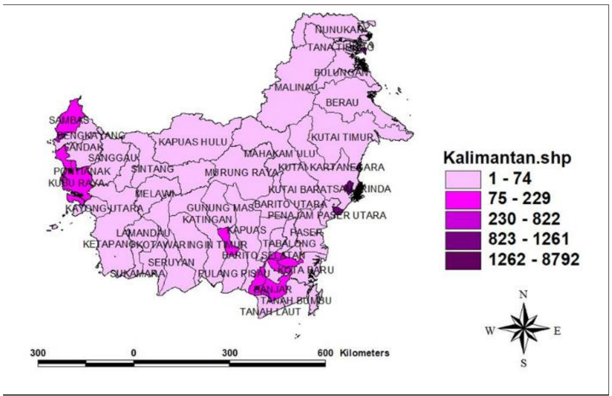


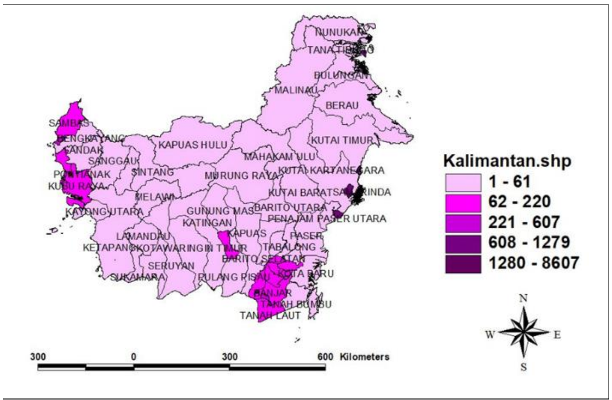
(a)The number of doctors x1 in 2020 and in 2021





(b)The number of tuberculosis cases x4 in 2020 and in 2021





(c)Population Density x6 in 2020 and in 2021

Figure 2 The mapping of spatial distribution of predictor variables

3.2. Spatio-temporal Model Estimation with Geographically Weighted Panel Regression

General model of GWPR at the i-th observation location i=1,2,...,56=1,2,…,56 and at the t-time t=1,2=1,2 is formulated in Equation (3)

$$\hat{y}_{it}^* = \hat{\beta}_0(u_{1i}, v_i) + \hat{\beta}_1(u_i, v_i)x_{it1}^* + \hat{\beta}_2(u_i, v_i)x_{it2}^* + \cdots + \hat{\beta}_g(u_i, v_i)x_{itg}^* \quad (3)$$

After successfully obtaining the parameter estimation results, the researchers further conducted an evaluation of the GWPR model estimator, which stated the relationship between the number of doctors, the number of hospitals, the number of villages/sub-districs with the Health care centers, the number of tuberculosis cases, the percentage of the elderly population, the population density, the percentage of the lower class population, and GRDP to the number of positive COVID-19 cases in Kalimantan for each location as shown in Equation 4.

$$\hat{y}^*_{1t} = 1{,}3 \times 10^{-12} + 22{,}643x^*_{1t} + 1110{,}353x^*_{2t} + 265{,}233x^*_{3t} - 19{,}261x^*_{4t} - 91{,}185x^*_{5t} + 35{,}397x^*_{6t} \; 501{,}483x^*_{7t} - 2{,}397x^*_{8t}; t = 1{,}2$$

$$\hat{y}^*_{2t} = -4{,}9 \times 10^{-12} - 27{,}518x^*_{1t} + 628{,}545x^*_{2t} + 663{,}691x^*_{3t} - 44{,}577x^*_{4t} - 2739{,}459x^*_{5t} + 41{,}407x^*_{6t} \; 2292{,}322x^*_{7t} - 2{,}155x^*_{8t}; t = 1{,}2$$

$$\hat{y}^*_{3t} = -1{,}47 \times 10^{-12} - 12{,}238x^*_{1t} + 1313{,}662x^*_{2t} + 285{,}328x^*_{3t} - 26{,}377x^*_{4t} - 1{,}394x^*_{5t} + 47{,}789x^*_{6t} \; 1188{,}972x^*_{7t} - 2{,}155x^*_{8t}; t = 1{,}2$$

$$\hat{y}^*_{56t} = -1{,}77 \times 10^{-12} - 14{,}490x^*_{1t} + 512{,}877x^*_{2t} + 262{,}943x^*_{3t} - 1202x^*_{4t} - 99.928x^*_{5t} + 0{,}002x^*_{6t} \; 87{,}011x^*_{7t} - 3{,}970x^*_{8t}; t = 1{,}2 \quad (4)$$

The measures of goodness used were the coefficient of determination (R^2) and Root Mean Square Error (RMSE). The comparison of the value of the measure of goodness can be seen in Table 3 as follows.

Table 3. Measures of goodness of the global panel regression model and the gwpr model

Model	R2 %	RMSE
Global Model	79,25	1415,17
GWR Model	79,88	1327,33
GWPR Model	96,99	538,09

The comparison of the global regression model, the GWR and GWPR models shows that the GWPR model is a better model to see the influence of predictor variables with an R2 value of 96.99% a value that is greater than the Global and GWR models

3.3 The Mapping of GIS Based on Spatio-temporal Model Estimator with Geographically Weighted Panel Regression

Regarding To The Results Of The Parameter Estimator Of The Gwpr Model, A Spatial Distribution Map Was Successfully Obtained For Each Predictor Variable. These Variables Were Able To Influence The Number Of Positive Covid-19 Cases In Kalimantan.

Figure 3 indicates a distribution map related to the calculation results of the number of doctors estimator in Kalimantan, which explained the level of influence provided by this variable on the increase or decrease in positive cases of COVID-19. Referring to table 4, it was found that the majority of doctors provided a positive influence with an interval of 0 – 26.17 on the number of positive cases of COVID-19 in Kalimantan. This showed that an increasing number of doctors was capable of reducing the number of positive cases of COVID-19.

Furthermore, the distribution map of the number of hospitals estimator is presented in Figure 4.

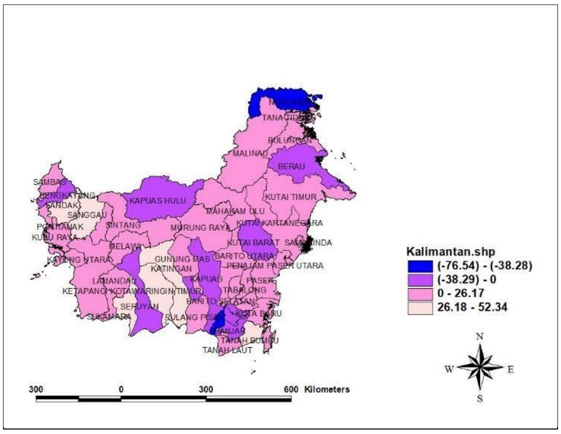


Figure 3 Distribution map of the number of doctors estimator

Table 4. Classification of the number of doctors estimator

Parameter Estimator Variable Number of Doctors	Regency/ City
(-76,54) – (-38,28)	Nunukan dan Barito Kuala
(-38,29) – 0	Barat, Berau, Bontang, Kapuas, Seruyan, Banjar, Tapin, Hulu Sungai Selatan, Bengkayang, dan Kapuas Hulu
0 – 26,17	Kutai Kartanegara, Kutai Timur, Penajam Paser Utara, Mahakam Ulu, Balikpapan, Samarinda, Malinau, Bulungan, Tana Tidung, Tarakan, Barito Selatan, Barito Utara, Sukamara, Lamandau, Pulang Pisau, Gunung Mas, Barito Timur, Murung Raya, Tanah Laut, Kotabaru, Hulu Sungai Tengah, Hulu Sungai Utara, Tabalong, Balangan, Banjar Baru, Sambas, Mempawah, Ketapang, Sintang, Sekadau, Melawi, Kayong Utara, Kubu Raya, Pontianak, dan Singkawang
26,18 – 52,34	Kotawaringin Bara, Kotawaringin Timur, Katingan, Tanah Bumbu, Banjarmasin, Landak, dan Sanggau

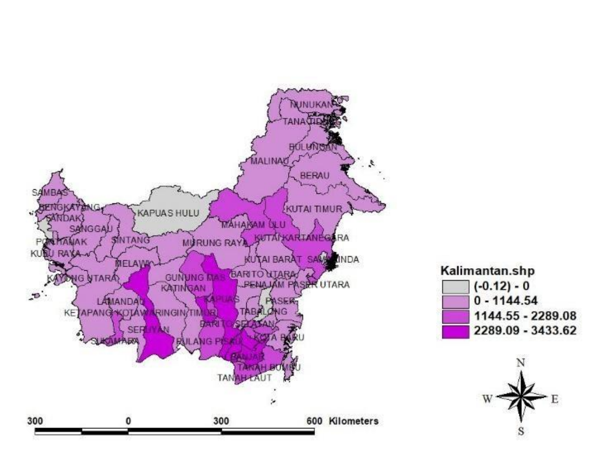


Figure 4 Distribution map of the number of hospital estimator

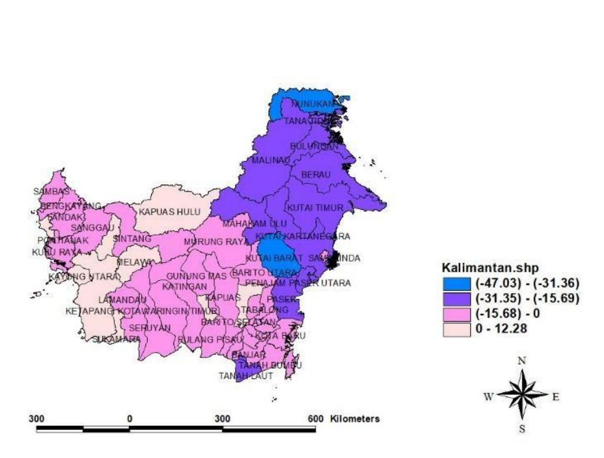


Figure 5 Distribution Map of the Number of Tuberculosis Cases Estimator

Figure 4 indicates the Distribution Map of the calculation results of the Number of Hospitals estimator in Kalimantan. By referring to Table 5, it was found that the majority of hospitals provided a positive influence with an interval of 0 – 1144.54 on the number of positive COVID-19 cases in Kalimantan. This certainly indicated that the high number of hospitals was capable of reducing the number of positive cases of COVID-19 in Kalimantan.

Table 5. Classification of the number of hospitals estimator

Parameter Estimator Variable Number of Hospitals	**Regency/ City**
(-0,12) – 0	marinda, Mempawah, dan Kapuas Hulu
0 – 1144,54	Paser,Kutai Barat, Kutai Timur, Berau, Penajam Paser Utara, Bontang, Malinau, Bulungan, Tana Tidung, Nunukan, Tarakan, Kotawaringin Barat, Kotawaringin Timur, Barito Selatan, Barito Utara, Lamandau, Katingan, Barito Timur, Murung Raya, Kotabaru, Tabalong, Balangan, Banjarmasin, Sambas, Bengkayang, Landak, Mempawah, Sanggau, Ketapang, Sintang, Kapuas Hulu, Sekadau, Melawi, Kayong Utara, Kubu Raya, Pontianak, dan Singkawang
1144,55 – 2289,08	Kutai Kartanegara, Mahakam Ulu, Balikpapan, Sukamara, Seruyan, Pulang Pisau, Gunung Mas, Tanah Laut, Hulu Sungai Selatan, Hulu Sungai Tengah, Hulu Sungai Utara, Tanah Bumbu, dan Banjar Baru
2289,09 – 3433,62	Kapuas, Palangka Raya, Banjar, Barito Kuala, dan Tapi

In addition, the distribution map of the number of tuberculosis cases estimator is shown in Figure 5.

Table 6 shows that the majority of tuberculosis cases had a negative influence with an interval of (-15.68) – 0 on the number of positive cases of COVID-19 in Kalimantan. This indicated that an increasing number of tuberculosis cases would be succeeding in increasing the number of positive cases of COVID-19 in Kalimantan.

Table 6. Classification of the Number of Tuberculosis Cases Estimator

Estimator of Tuberculosis Case Rate	**Regency/ City**
,03) – (-31,36)	Kutai Barat, Bontang, dan Nunukan
,35) – (-15,69)	Paser, Kutai Kartanegara, Kutai Timur, Berau, Penajam Paser Utara, Mahakam Ulu, Balikpapan, Malinau, Bulungan, Tana Tidung, Tarakan, Tanah Laut, Banjarmasin, dan Banjar Baru
-15,68) – 0	Samarinda, Kotawaringin Barat, Kotawaringin Timur, Kapuas, Barito Utara, Lamandau, Seruyan, Katingan, Pulang Pisau, Gunung Mas, Barito Timur, Murung Raya, Kotabaru, Banjar, Barito Kuala, Tapin, Hulu Sungai Selatan, Hulu Sungai Tengah, Hulu Sungai Utara, Tabalong, Tanah Bumbu, Balangan, Sambas, Bengkayang, Landak, Sanggau, Sintang, Kubu Raya, Pontianak, dan Singkawang
0 – 12,28	Barito Selatan, Sukamara, Mempawah, Ketapang, Kapuas Hulu, Sekadau, Melawi, dan Kayong Utara

The distribution map of the population density estimator can be seen in Figure 6. Regarding to Table 20, it was found that the majority of population density provided a positive influence with an interval of 0 – 30.92 on the number of positive cases of COVID-19 in Kalimantan. This indicated that the high population density was capable of increasing the number of positive cases of COVID-19 in Kalimantan, by assuming that other variables remain constant.

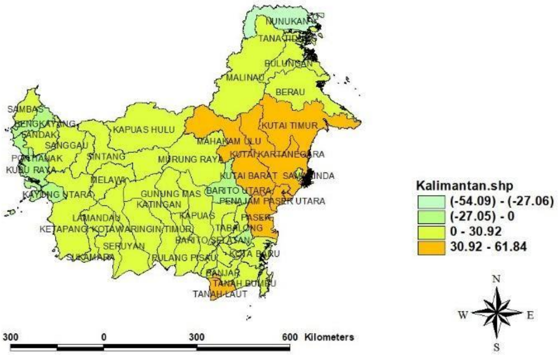


Figure 6 Distribution Map of the Population Density Estimator

Table 7. Classification of the Population Density Estimator

Population Density Estimator	Regency/ City
(-54,09) – (-27,06)	Nunukan
(-27,05) – 0	Balangan, Bengkayang, Mempawah, Kayong Utara, Kubu Raya, dan Pontianak
0 – 30,92	Berau, Samarinda, Malinau, Bulungan, Tana Tidung, Tarakan, Kotawaringin Barat, Kotawaringin Timur, Kapuas, Barito Selatan, Barito Utara, Sukamara, Lamandau, Seruyan, Katingan, Pulang Pisau, Gunung Mas, Barito Timur, Murung Raya, Palangka Raya, Kotabaru, Banjar, Barito Kuala, Tapin, Hulu Sungai Selatan, Hulu Sungai Tengah, Hulu Sungai Utara, Tabalong, Tanah Bumbu, Sambas, Landak, Sanggau, Ketapang, Sintang, Kapuas Hulu, Sekadau, Melawi, dan Singkawang
30,93 – 61,84	Paser, Kutai Barat, Kutai Kartanegara, Kutai Timur, Penajam Paser Utara, Mahakam Ulu, Balikpapan, Bontang, Tanah Laut, Banjarmasin, dan Banjar Baru

4. CONCLUSION

The Spatio-temporal with GWPR model was capable of providing good estimator results, through the consideration of location and time aspects, more informative, varied and efficient. Moreover, this model was considered to succeed in avoiding multicollinearity problems, was better at studying dynamic changes, and was able to measure unobservable effects on true cross section and true time series data. The highest influence found in this study related to an increase in the number of positive cases was the deficiency of health workers in several areas, thus leading to slow handling of COVID-19. In addition, the high population density was also able to result in an increase in the number of COVID-19 spreads.

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