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# Application of a Geographically Weighted Regression on the Positivity Rate of Covid-19 in East Java

**Fitri Laila Ramadhani[1], Toha Saifudin[2], Elly Ana[3], Sediono[4]**

Statistics Study Program, Departement of Mathematics, Airlangga University, Surabaya, Indonesia
[1]fitrilailaramadhani12@gmail.com
[2]Corresponding author: tohasaifudin@fst.unair.ac.id
[3]elly-a@fst.unair.ac.id
[4]sediono101@gmail.com

***Abstract:*** *East Java is the province with the highest number of confirmed Covid-19 cases in Indonesia and has a positivity rate of 30.7%. The positivity rate in East Java is high because it is still above the positivity rate of 17.8% and above the standard set by WHO and the Ministry of Health, which is <5%. The high positivity rate triggers fear and panic that has an impact on health, public welfare and the quality of human resources. The purpose of this research is to analyze the factors that influence the positivity rate in each regency/city in East Java. So, in modeling this phenomenon, the Geographically Weighted Regression (GWR) approach is used because this approach can overcome regional diversity which produces an estimator of model parameters for each observation location. The factors that are considered to influence the positivity rate are the percentage of households that have access to proper sanitation, the open unemployment rate, the percentage of poverty and the percentage of households that have a source of drinking water from protected wells. The results showed that the positivity rate in most areas of East Java was influenced by the open unemployment rate.*

**Keywords**: positivity rate of Covid-19, Geographically Weighted Regression, East Java

## 1. INTRODUCTION

World Health Organization (WHO) reports that Covid-19 began with the emergence of a mysterious Pneumonia case of unknown etiology in Wuhan China on December 31, 2019 [1]. Covid-19 began to spread, first to neighboring parts of China, and eventually to several countries, causing unprecedented panic and fear. Worse, the number of infections is starting to increase exponentially, with a large number of deaths in different parts of the world [1]. So that it became one of the WHO's basis for deciding Covid-19 to be a Public Health Emergency of International Concern (PHEIC). To date, there are 220 countries that have confirmed Covid-19, including Indonesia [6]. March 18, 2020 was the first day that a confirmed case of Covid-19 was reported in East Java. The first cases reported were 8 confirmed cases that occurred in 3 regencies/cities, namely 6 cases in Surabaya City, 1 case in Malang City, and 1 case in Malang Regency. Covid-19 cases then slowly increased and spread in all regencies/cities in East Java, even East Java had occupied the province with the highest number of confirmed cases in Indonesia surpassing other provinces [3].

Positivity rate is one of the epidemiological indicators of the Covid-19 response that is used worldwide to monitor the development of the Covid-19 pandemic by the WHO and the Ministry of Health [7]. To date, the positivity rate has been mainly studied in light of its association with confirmed cases [4]; for example, it is used to estimate the prevalence of Covid-19 in various countries. The positivity rate is the result of the calculation of the number of people with positive test results divided by the number of people who were examined in the same time span. The number of positive examinations and the number of people who were tested were only taken from the number of examinations and the number of people who carried out the first examination (initial diagnosis). According to the standards set by WHO and the Ministry of Health, the positivity rate is said to be good if the value is <5%.

According to the Covid-19 projection, positivity rate fluctuates but the trend shows an increase. In 2020, the positivity rate at 17.8% [9]. East Java has a positivity rate of 30.7%.district with the positivity rate in East Java is Lumajang, which is 93%, while positivity rate is Bangkalan, which is 14.4% [3]. This is because the test capacity in East Java is still below the target. So that there are no regencies/cities that have achieved the WHO and Ministry of Health indicators for a positivity rate <5%.

The high number positivity rates triggered fear and panic in the government which prompted them to institute several actions with broad impacts on society, the economy, politics, and also the environment. Many countries have imposed lockdowns in their countries such as border restrictions, prohibiting non-citizens from staying, as well as disabling transportation networks which have resulted in a total cessation of flights, both domestic and international [1]. Likewise in Indonesia which decided on Pembatasan Sosial Berskala Besar (PSBB). PSBB is a regulation launched by the government in several regions to reduce the level of virus spread in the community [8]. The worldwide economy has stalled, affecting all sectors especially tourism and other sectors. In Indonesia in April 2020, approximately 1.5 million employees were laid off. Then the number of tourists also decreased by 6,800 per day, the lack of tourists also had an impact on restaurants, trade, usaha mikro, kecil dan menengah (UMKM) [5].

Socially, the emergence of Covid-19 brought unprecedented pain, fear, suffering and chaos as people, in the thousands, and millions were hospitalized, separated from their loved ones. The devastation is even worse for those traveling abroad, with lockdowns and transportation restricted, having to remain displaced until the measures are relaxed or lifted. The measures that have been put in place in various countries are also having an unprecedented impact on the viability of living, especially in urban areas where people are forced to stay indoors, with limited supplies [1], without social interaction, and with the stress of losing their jobs and sources of livelihood. Residents of several cities in Indonesia also called for the lifting of the PSBB. Such issues arise when the United Nations World Food Program has warned that the effects of Covid-19 will result in an increase in the number of acute hunger, affecting more than 265 million people worldwide [2].

Positivity rate is influenced by factors that are not the same in each region. This is due to the differences in the characteristics of an area and the distance between regions. Thus, this research needs to pay attention to the element of location (spatial). One of the spatial models used to address regional diversity is Geographically Weighted Regression (GWR). GWR is a statistical method developed from global regression with a local form that pays attention to spatial or location aspects so that the estimated parameters vary from location to location.

According to Richard S. Whittle and Ana Diaz (2020) who analyzed socio-economic factors that have the potential to explain variations between environments in the positivity rate test in New York City using the Besag-York-Mollié model and the conclusion is that there is a relationship between environment and large dependent youth population, population density, low income, and predominantly black environment and positivity rate Covid-19. Ilham (2020) who discussed modeling the number of Covid-19 cases in West Java using Geographically Weighted Regression which resulted in the conclusion that modeling the number of Covid-19 cases in West Java locally through GWR has a higher coefficient of determination than modeling globally through linear regression. The modeling results show that 6 groups of districts/cities are formed which are mostly influenced by the percentage of poverty.

Therefore, this research will discuss the modeling of the positivity rate in East Java using the GWR approach with the aim of knowing the factors that affect the positivity rate in East Java. This research uses secondary data from the East Java Provincial Health Office and the Central Bureau of Statistics of East Java Province in 2021 with 4 predictor variables, namely the percentage of households that have access to proper sanitation, the open unemployment rate, the percentage of poverty and the percentage of households that have a drinking water source. from sheltered wells. Factors that have a significant influence are used as consideration for the government in each regency/city in East Java in making various efforts to improve a healthy life, support the welfare of people at various ages and improve the quality of human resources in order to overcome poverty and unemployment.

## 2. RESEARCH METHODS

### 2.1 Source of Data

This study used secondary data obtained from the Health Profile of East Java in 2020 by the Health Office of East Java in 2021. In addition, data was also obtained from the Province of East Java in Figures 2021 by the Central Statistics Agency of East Java in 2021. The data consists of the positivity rate in East Java based on regencies/cities in 2020 along with influencing factors. This research uses data from 38 regencies/cities in East Java, from Pacitan regency to Batu city.

### 2.2 Research Variables

**Table 1**: Research Variables

| Variable | Note | Data Type | Source |
|---|---|---|---|
| Y | *Positivity Rate* (%) Covid-19 | Continuous | Health Profile of East Java in 2020 |
| $X_1$ | Percentage of Households with Access to Proper Sanitation | Continuous | Health Profile of East Java in 2020 |
| $X_2$ | Open Unemployment Rate | Continuous | East Java Province in Figures 2021 |
| $X_3$ | Percentage of Poverty | Continuous | East Java Province in Figures 2021 |
| $X_4$ | Percentage of Households Having Drinking Water Sources from Sheltered Wells | Continuous | East Java Province in Figures 2021 |

According to this table, the research variables used are 5 variables consisting of 1 response variable and 4 predictor variables. In addition, there are also geographic variables, namely $u_i$ form of longitude and $v_i$ form of latitude of each location.

### 2.3 Step of the Research

The analysis in this study was carried out with the help of *Microsoft Excel*, *GWR* R software, *ArcView* 4.0 software and *software* GIS 3.2. The following are the steps of data analysis carried out in this study.

1. Collecting data used as research variables.
2. Conducting a descriptive analysis of each research variable with the following steps:
   a. Describing all research variables with statistics on mean, variance, minimum value and maximum value.
   b. Describe each research variable in the form of a thematic map using *software* ArcView GIS 3.2
3. Modeling the *positivity rate* of Covid-19 in East Java by regencies/cities using a multiple linear regression model approach or the *Ordinary Least Square* (OLS) method with the following steps:
   a. Estimating the parameters of the multiple linear regression model or the *Ordinary Least Square* (OLS) method.
   b. Performing the classical multiple linear assumption test, namely the residual normality and multicollinearity tests.
   c. Testing the significance of the parameters on the multiple linear regression model simultaneously and partially.
4. Testing the spatial assumptions on the *positivity rate* of Covid-19 with the following steps.
   a. Testing *spatial dependence* on the *positivity rate* of Covid-19 using the *Moran's I*. If *the p-value* <α then the *positivity rate* of Covid-19 *spatial dependence*.
   b. Testing *spatial heterogeneity* data *positivity rate* using the *Breusch-Pagan*. If the p-value <α then the *positivity rate* of Covid-19 *spatial heterogeneity*.
5. Modeling the *positivity rate* of Covid-19 in East Java based on regencies/cities using the GWR model approach using *software* with the following steps.
   a. Determine the minimum and maximum distance values for *latitude* and *longitude* using *software* R
   b. Determine the weighting matrix using the *Fixed Gaussian Kernel* and *Fixed Bisquare Kernel functions*.
   c. Determine the optimal bandwidth value based on the *Cross Validation* (CV) criteria.
   d. Estimating the parameters of the GWR model using *bandwidth* optimal
   e. Performing the *goodness of fit test* the GWR model.
   f. Perform a partial parameter test.
6. Identify the factors that have a significant effect on *positivity rate* of Covid-19 in each regency/city in East Java.
7. Determine the best model for *positivity rate* of Covid-19 in every regency/city in East Java Province.
8. Create a thematic map of the *positivity rate* of Covid-19 in each regency/city in East Java Province based on factors that have a significant influence using *software* ArcView GIS 3.2
9. Draw conclusions and suggestions.

## 3. RESULTS AND DISCUCCION

### 3.1 DESCRIPTIVE STATISTICS

The predictor variable (X) used to see its effect on the response variable to the positivity rate Covid-19 (Y) in East Java includes the percentage of households with access to proper sanitation ($X_1$), the open unemployment rate ($X_2$) Percentage of Poor Population ($X_3$) and Percentage of Households Having Drinking Water Sources from sheltered wells ($X_4$).

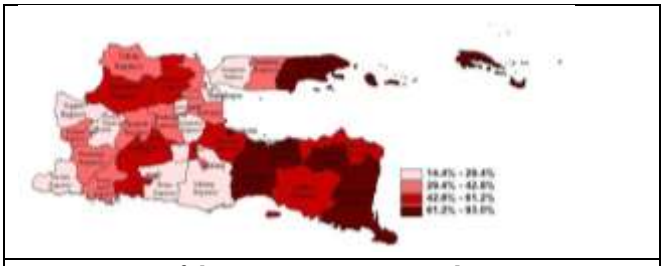
**Table 2**: Descriptive Statistics of Variables

| Variable | Mean | StDev | Varians | Min | Max |
|---|---|---|---|---|---|
| $Y$ | 44,39 | 19,4 | 376,49 | 14,4 | 93 |
| $X_1$ | 94,36 | 8,08 | 65,37 | 69,9 | 100 |
| $X_2$ | 5,624 | 2,003 | 4,014 | 2,28 | 10,97 |
| $X_3$ | 11,021 | 4,568 | 20,865 | 3,89 | 22,78 |
| $X_4$ | 15,742 | 13,477 | 181,636 | 0,1 | 43,68 |

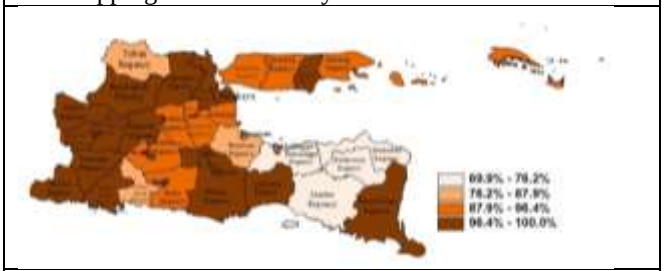
Table 2 it can be seen that the mean, standard deviation, variance, minimum and maximum for each variable. From the response variables, the mean value is 44.39, the standard deviation value is 19.40, the variance value is 376.49, the minimum value is 14.40 by Bangkalan regency and the maximum value is 93 by Lumajang regency.

### 3.2 Thematic Map of Research Data

Thematic map aims to display the visualization of research data which will be grouped by mapping based on the value of each variable in each of the 38 regencies/cities in East Java. The following is a map for the distribution of research data:



a. Mapping of the Positivity Rate Covid-19



b. Mapping the Percentage of Households with Access to Adequate Sanitation

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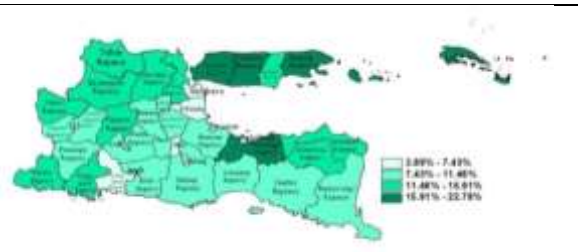
c. Mapping the Open Unemployment Rate



d. Mapping the Percentage of Poverty

e. Mapping the Percentage of Households Having Drinking Water Sources from Protected Wells

Figure 1. Thematic Map

### 3.3 Modeling Positivity Rate of Covid-19 in East Java Using Ordinary Least Square (OLS)

Prior to the GWR modeling, a linear regression will be conducted as a global model using the OLS method. The estimation results from global regression are as follows:

**Table 3**: Estimation of Linear Regression

| Variable | Estimation | t | *p-value* | VIF |
|---|---|---|---|---|
| Intersept | 144,183278 | 3,581766 | 0,001 | |
| $X_1$ | -0,659566 | -1,734719 | 0,092 | 1,09 |
| $X_2$ | -4,603774 | -2,492451 | 0,018 | 1,58 |
| $X_3$ | -0,907281 | -1,164397 | 0,253 | 1,46 |
| $X_4$ | -0,105719 | -0,400047 | 0,692 | 1,47 |

Detect the presence of multicollinearity symptoms, it is necessary to pay attention to the VIF value. The results showed that none of the predictor variables had a VIF value of more than 10, so it could be concluded that there was no multicollinearity. Based on the results of the simultaneous test, the F value = 2.63 with a p-value of 0.052 means that the predictor variable has a significant simultaneous effect on the positivity rate Covid-19. While the partial test results in Table 3 show that the percentage of households that have access to proper sanitation and the open unemployment rate have a significant individual effect on the positivity rate Covid-19Based on the global regression model, the AIC value is 333.677171 and the value $R^2$ is 24.19%.

### 3.4 Assumptions Test on Spatial Data Analysis

Dependency Spatial

Dependency spatial is carried out to see whether observations at one location affect observations at other locations that are close together. One of the tests that can be used to identify the presence of spatial dependencies is the Moran's I using the software R . The following hypothesis is used.

$H_0$: $I = 0$ (No spatial dependency)
$H_1$: $I \neq 0$ (Spatial dependency)

Based on *output* on *software* R, obtained a *p-value* of 0.000477068 less than the value of 5%. Thus, the decision taken is to reject H0 so that the conclusions obtained are that there is a spatial dependence on the data *positivity rate* of Covid-19.

Heterogeneity Spatial

Heterogeneity spatial was conducted to determine whether there were differences in characteristics at each observation location. Given the spatial heterogeneity, the model will produce different regression parameters at each observation location. This test was carried out using the *Breusch-Pagan* with the following hypothesis.

$H_0$: $\sigma_1^2 = \sigma_2^2 = \cdots = \sigma_n^2 = \sigma^2$ (homoscedasticity)

$H_1$: minimal ada satu $\sigma^2(u_i, v_i) \neq \sigma^2(u_j, v_j)$ untuk $i \neq j$ (heteroscedasticity)

Based on output on software R, obtained p-value of 0.06581 less than the value of 10%. Thus, the decision taken is to reject H0 so that the conclusions obtained are that there is spatial heterogeneity in the data positivity rate of Covid-19.

### 3.5 Modeling Positivity Rate Covid-19 in East Java Using Geographically Weighted Regression (GWR)

Modeling using GWR by determining the best weighting first. Determination of the best weighting by having a weight with the smallest AIC value. After determining the best weighting for the GWR model, then selecting the optimal bandwidth based on the kernel weighting.

The best weighting is then used to estimate the parameters in each regency/city in East Java. The comparison of the AIC values for each kernel function weighting is in Table 4 below.

**Table 4**: Aic and $R^2$of Weight Type

| Weight Type | AIC | $R^2$ |
|---|---|---|

| | | |
|---|---|---|
| *Fixed Gaussian Kernel* | 314,093419 | 0,671286 |
| *Fixed Bi-square Kernel* | 314,523116 | 0,645116 |

Table 4 shows that the Fixed Gaussian Kernel has the smallest AIC value of 314 .093419 and the $R^2$ highest is 67.13%. Thus, the best weighting used for the GWR model in this study is the Fixed Gaussian Kernel.

### 3.6 Goodness of fit of GWR Model

Next, a model suitability test was carried out to see if the GWR model produced was in accordance with the positivity rate Covid-19. The hypothesis used is as follows.

$H_0$: $\frac{\partial \beta_k(u,v)}{\partial u} = 0$ dan $\frac{\partial \beta_k(u,v)}{\partial v} = 0$ for all k (GWR model is not fit)

$H_1$: $\frac{\partial \beta_k(u,v)}{\partial u} \neq 0$ dan $\frac{\partial \beta_k(u,v)}{\partial v} \neq 0$ for all k (GWR model is fit)

Criteria test is rejected $H_0$ if $F > F_{(\alpha,df_1,df_2)}$ atau $F > F_{(0.1,8.286,25.714)}$ or $F >$ 1,911084. The results of the conformity test of the GWR model are presented in Table 5.

**Table 5**: Results of goodness of fit

| Source | SS | DF | MS | F |
|---|---|---|---|---|
| Global Residuals | 10560,731 | 33,000 | | |
| GWR Improvement | 5981,642 | 9,072 | 659,317 | |
| GWR Residuals | 4579,089 | 23,928 | 191,373 | 3,445186 |

Table 5 shows that value F of 3,445186 > $F_{(0.1,9,072,23,928)}$ of 1,904886 so that the decision taken is to reject $H_0$. Thus, the conclusion obtained is that the GWR regression model obtained is fit for the positivity rate Covid-19.

### 3.7 Partial Test

Partial test of the GWR model was carried out to determine the factors that significantly affect *positivity rate* of Covid-19 in each regency/city in East Java. The test statistic used is the t. With the test criteria, namely reject $H_0$ if the value of $|t_{hit}| > t_{(0.1;23,928)} = 1{,}317948$.

Furthermore, to understand the partial test results will be presented regarding parameter testing at locations $(u_9, v_9)$, namely Jember Regency. The hypothesis used is as follows.

**Table 6**: Partial Test of GWR Model in Jember Regency

| Parameter | Estimation | $t_{hit}$ | Decision |
|---|---|---|---|
| $\beta_0$ | 119,581594 | 3,227767 | - |
| $\beta_1$ | 0,181976 | 0,454694 | Terima $H_0$ |
| $\beta_2$ | -10,383547 | -4,711141 | Tolak $H_0$ |
| $\beta_3$ | -1,494586 | -1,807141 | Tolak $H_0$ |
| $\beta_4$ | -0,300260 | -0,94179 | Terima $H_0$ |

From Table 6, the variable that has a significant effect on the positivity rate Covid-19 in Jember Regency are $X_2$ and $X_3$. So that the GWR model is obtained as follows.

$\hat{y}_9 = 119{,}581594 - 10{,}383547X_2 - 1{,}494586X_3$

The hypothesis used to test the parameters in the city of Surabaya is as follows.

$H_0$: $\beta_k(u_{37}, v_{37}) = 0; k = 1,2,3$

$H_1$: $\beta_k(u_{37}, v_{37}) \neq 0$

**Table 7**: Partial Test of GWR Model in Surabaya

| Parameter | Estimation | $t_{hit}$ | Decision |
|---|---|---|---|
| $\beta_0$ | 142,214139 | 3,633209 | - |
| $\beta_1$ | -0,596730 | -1,586944 | Tolak $H_0$ |
| $\beta_2$ | -5,119333 | -3,217709 | Tolak $H_0$ |
| $\beta_3$ | -0,645417 | -0,934015 | Terima $H_0$ |
| $\beta_4$ | -0,399784 | -1,691357 | Tolak $H_0$ |

Based on Table 7, it is known that the variables that have a significant effect on the positivity rate Covid-19 are $X_1$, $X_2$ and $X_4$. So that the GWR model is obtained as follows.

$\hat{y}_{37} = 142{,}214139 - 0{,}596730X_1 - 5{,}119333X_2 - 0{,}399784X_4$

Based on the partial test results of the GWR model parameters in Jember Regency and Surabaya City, it shows that the predictor variables that have a significant effect in Jember Regency are not necessarily influential in the city of Surabaya, so it can be concluded that there are different variables that have a significant effect in each regency/city in East Java. Table 8 shows the predictor variables that have a significant effect on each regency/city in East Java.

**Table 8**: Significance of Variables Based on Location

| Location | Significant Variables |
|---|---|
| Banyuwangi Regency, Pasuruan Regency | $X_1$, $X_2$, and $X_3$ |
| Blitar Regency, Kediri Regency, Malang Regency, Sidoarjo Regency, Mojokerto Regency, Jombang Regency, Lamongan Regency, Gresik Regency, Bangkalan Regency, Kediri, Blitar, Malang, Pasuruan, Mojokerto, Surabaya, Batu | $X_1$, $X_2$, and $X_4$ |
| Lumajang Regency, Jember Regency, Bondowoso Regency, Situbondo Regency, Probolinggo Regency, Sampang Regency, Pamekasan Regency, Sumenep Regency, Probolinggo | $X_2$ and $X_3$ |
| Ponorogo Regency, Tulungagung Regency, Nganjuk Regency, Madiun Regency, Magetan Regency, Ngawi Regency, Bojonegoro Regency, Tuban Regency, Madiun | $X_2$ and $X_4$ |
| Trenggalek Regency | $X_2$ |

| | |
|---|---|
| Pacitan Regency | There are no significant variables |

Based on the results in Table 7, 6 groups of regencies/cities were formed based on significant variables. In general, the variables that have a significant effect on the positivity rate of Covid-19 in East Java are grouped based on the location of adjacent areas. For example in Regency Jombang, the variables that have a significant effect on the district are the same as the variables that have a significant effect on the surrounding districts such as Blitar Regency, Kediri Regency, Malang Regency, Sidoarjo Regency, Mojokerto Regency, Lamongan Regency, Gresik Regency, Bangkalan Regency, Kediri, Blitar, Malang, Pasuruan, Mojokerto, Surabaya and Batu.

Group 1 (Banyuwangi Regency and Pasuruan Regency) is influenced by the percentage of households that have access to proper sanitation ($X_1$), the open unemployment rate ($X_2$), and the percentage of poverty ($X_3$). Group 2 (Blitar Regency, Kediri Regency, Malang Regency, Sidoarjo Regency, Mojokerto Regency, Jombang Regency, Lamongan Regency, Gresik Regency, Bangkalan Regency, Kediri, Blitar, Malang, Pasuruan, Mojokerto, Surabaya, Batu) is influenced by the percentage of households that have access to proper sanitation ($X_1$), the open unemployment rate ($X_2$) and the percentage of households that have a source of drinking water from protected wells ($X_4$). Group 3 (Lumajang Regency, Jember Regency, Bondowoso Regency, Situbondo Regency, Probolinggo Regency, Sampang Regency, Pamekasan Regency, Sumenep Regency, Probolinggo Regency) is affected by the open unemployment rate ($X_2$) and the percentage of poverty ($X_3$). Group 4 (Ponorogo Regency, Tulungagung Regency, Nganjuk Regency, Madiun Regency, Magetan Regency, Ngawi Regency, Bojonegoro Regency, Tuban Regency, Madiun) is affected by the Open Unemployment Rate ($X_2$) and the percentage of households that have a source of drinking water from protected wells ($X_4$). Group 5 (Trenggalek Regency) is affected by the Open Unemployment Rate ($X_2$). Group 6 (Pacitan Regency) is not affected by the variables studied.

Figure 2 shows the distribution of predictor variables that have a significant effect on each district/city in East Java. Based on Figure 2, it can be seen that there are the same colors for several adjacent locations.


Figure 2. Thematic Map of Factors That Have a Significant Influence on Positivity Rate the Covid-19

## 4. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the analysis, it is concluded that the Geographically Weighted Regression with Kernel Fixed Gaussian determined by the AIC and values $R^2$. The AIC value of the GWR model is smaller than the OLS model, which is 314.093419 and the coefficient of determination $R^2$ is 67.13 % greater than the OLS model, where the results of modeling the positivity rate Covid-19which is largely influenced by the open unemployment rate. As for the Pacitan Regency is influenced by factors other than the percentage of households that have access to proper sanitation, the open unemployment rate, the percentage of poverty and the percentage of households that have a source of drinking water from protected wells.

Suggestions from this study are a) The factors that have the most significant influence on the positivity rate are the open unemployment rate. It is hoped that these factors can be taken into consideration for the Regional Government of East Java Province in supporting the welfare of people at various ages and improving the quality of human resources. b) Adding significant influencing factors that can affect the positivity rate in East Java so that a better model is obtained. These factors are social factors and vaccination factors in the following year.

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