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IMPLEMENTATION OF MIXED GEOGRAPHICALLY WEIGHTED REGRESSION MODEL TO ANALYZE SOCIAL ASSISTANCE BUDGET IN EAST JAVA

Putri Utami[1], Denny Nurdiansyah[2*], Alif Yuanita Kartini[3]

[1,2,3]Statistics, Faculty of Science and Technology, Universitas Nahdlatul Ulama Sunan Giri
Jln. Ahmad Yani No.10, Jambean, Sukorejo, Bojonegoro Regency, 62115, Indonesia

Corresponding author's e-mail: * ***denny.nur@unugiri.ac.id***

ABSTRACT

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Social assistance (BANSOS) is aid provided by the government to low-income communities in the form of money, goods, or services. Understanding the allocation and influencing factors of social assistance in East Java is crucial for effective distribution. Mixed Geographically Weighted Regression (MGWR) combines global and local regression models to address spatial variability in the data. This study aims to develop an MGWR model with a fixed kernel weighting function for social assistance budgets in East Java in 2022. Specifically, it seeks to identify which factors, based on spatial heterogeneity, can be classified as global variables or local variables that can be modeled using MGWR. The study employs the Mixed Geographically Weighted Regression (MGWR) method with a fixed Gaussian kernel to analyze social assistance budget data and economic factors in East Java for 2022. Models OLS, GWR, and MGWR are applied and evaluated using the Akaike Information Criterion (AIC) to identify the best-performing model. The MGWR model with a fixed Gaussian kernel is the best for the social assistance budget in East Java, yielding a lower AIC compared to OLS and GWR models. The globally influential factor in this model is economic growth ($X4$). This research is limited to data from 2022, which may not reflect long-term trends. Additionally, the analysis is confined to East Java, so generalizing results to other regions should be done cautiously. Data quality and completeness may affect the findings. This study provides original contributions by applying the MGWR method to social assistance budgets in East Java. This allows for a detailed understanding of influencing factors both globally and locally. The approach offers a more accurate model than OLS and GWR and highlights economic growth as a significant global factor in determining social assistance budgets.

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1. INTRODUCTION

Poverty has become an inherent phenomenon in life in developing countries. Indonesia is a developing country with great natural resource potential to improve the welfare of its people and alleviate poverty. However, many Indonesians still struggle to escape from the poverty threshold. Therefore, poverty in Indonesia is increasing from year by year. One of the root causes of poverty in Indonesia is the high income level between regions and social groups, unequal income distribution, and the widening gap between the poor in Indonesia [1]. Poverty is also the development of various fields characterized by high rates of unemployment, underdevelopment, and unhappiness, which are caused by social changes, including natural disasters, layoffs, suffering from socio-economic changes, and population growth, but insufficient income to meet primary (essential) needs [2].

Factors that influence the rise and fall of the poor population in East Java are unemployment, human development index (HDI), and economic income, where the relationship between unemployment and poverty is related to welfare [3]. Social welfare policy is a series of principles, actions, and frameworks by the government to protect the social welfare of individuals, families, and communities. Therefore, the government established a social assistance program (BANSOS) [4]. These assistance programs include essential food assistance, cash assistance (BST), direct cash assistance (BLT), free electricity, pre-employment cards, wage subsidies for workers, and direct money (BLT) for micro businesses [5]. Research on East Java is highly significant, considering the province's major contribution to the national economy and its complex socio-economic challenges. Gender inequality in economic access, for instance, has become a significant driver of poverty in this region, necessitating integrated female empowerment within poverty alleviation policies [6]. Optimizing budget distribution could enhance community welfare and support inclusive development in East Java.

Social Assistance (BANSOS) is assistance in the form of money, goods, or services the government provides to the community [7]. The social assistance program is part of the social security program as a form of responsibility and concern of the central government or local government for the poor and neglected [8]. Social assistance programs, namely programs provided by the government to the poor and disadvantaged, increase the economic capacity and welfare of the community according to predetermined and selective criteria. People have the right to adequate clothing, food, and shelter to build a prosperous society [9]. Social Assistance attracts a lot of public attention because it is interested in carrying out local government duties to realize welfare for the community [10]. The social assistance Program is social security in the form of government responsibility that handles the difficulties of underprivileged and neglected people at the lower and lowest levels [11]. BANSOS from the government still has many obstacles because the distribution is not on target, is ineffective and uneven, and there is misappropriation of funds and a reduction in the amount received [12]. The common problem is that a policy cannot know whether or not there are predictors of social assistance, such as the unemployment rate, HDI, and economic income. For this problem, regression modeling analysis is needed. Regression analysis is an analysis used to measure whether there is a relationship between predictor variables and response variables [13].

Previous research on social assistance conducted by Harahap [13] used GWR and MGWR to calculate the number of poor people. Other regression modeling in spatial cases usually uses the Geographical Weighted Regression (GWR) model. GWR is a statistical method that can be used to overcome spatial heterogeneity. GWR modeling uses a weighting matrix whose size depends on the proximity between locations and produces model parameter estimates that are local to each location and different from other locations [15]. Further research related to MGWR is in the case of MGWR Modeling on the Poverty Level in Central Java Province [16].

The number of poor people was analyzed spatially to see if it was influenced by predictor variables such as population percentage, minimum wage, open unemployment rate, and education level [13]. In contrast, this study focuses on the poverty percentage as the key variable to examine whether it has a significant spatial effect on the determination of the BANSOS budget, along with other predictor variables such as open unemployment rate, gross regional domestic product, and economic growth.

Geographic conditions greatly affect the social life of the community, and people who live in various regions have different characteristics. Thus, it is necessary to propose research entitled “Implementation of the Mixed Geographically Weighted Regression Model to Analyze the Social Assistance Budget in East Java.”

2. METHODS

Material and Data

The data source used in this study is secondary data in the form of social assistance fund budget data from the East Java Central Bureau of Statistics website, along with predictor variables, namely, the open unemployment rate, the percentage of poverty, GRDP, and economic growth. The data were obtained from the range of 2022.

Research Method

The variables used in this study consisted of one response variable and four predictor variables. The BANSOS budget was used as a predictor variable, along with the open unemployment rate, poverty percentage, GRDP, and economic growth. The following is an explanation of the definition of research variables.

Table 1. Definition of Research Variables

No	Variable	Measurement Scale	Description
1	Y	Ratio	BANSOS budget
2	X_1	Ratio	Open Unemployment Rate
3	X_2	Ratio	Poverty Percentage
4	X_3	Ratio	Gross Regional Domestic Product
5	X_4	Ratio	Economic Growth

The following is the sequence of steps taken in this research.

1. Performing data modeling starts with entering observation data.
2. Using descriptive statistics to identify data characteristics on the BANSOS Budget variable and its predictor variables.
3. Displaying the Ordinary Least Square (OLS) model output with the help of GWR4 software, where the steps are given as follows:
   3.1. Estimating the parameters of the multiple regression analysis model with the OLS method, which contains predictor and response variables.
   3.2. Conduct a parameter significance test with a t-test and difference of Criterion (DoC).
4. Estimate GWR model parameters with the maximum likelihood estimator (MLE) method and kernel approach containing cartesian, response, and predictor variables. The kernels used consist of fixed Gaussian (distance), fixed bi-square (distance), adaptive bi-square (NN), and adaptive Gaussian (NN). This estimation produces the optimal bandwidth iteratively based on the minimum AIC. AIC contains RMSE in the mathematical formula, and most of the values are not much different from BIC.
5. Conduct geographical variability tests on local and global coefficients.
6. Obtain the best model based on the smallest AIC.
7. Interpreting the effect of predictor variables on response variables.

3. RESULTS

Of the 38 districts in East Java, the research variables used are the social assistance budget, open unemployment rate, percentage of poverty, GRDP, and economic growth. In this study, descriptive statistics were used using the help of R software which the output results in the table as follows:

. **Table 2. Descriptive statistics of research variables**

Variable	Number of Districts	Mean	Standard Deviation	Minimum	Maximum
BANSOS Budget (Y)	38	197.1	109.3	18.6	502.9
Open Unemployment Rate (X_1)	38	5.273	1.775	1.360	8.800
Poverty Percentage (X_2)	38	72.969	5.077	63.390	82.740

Variable	Number of Districts	Mean	Standard Deviation	Minimum	Maximum
GRDP (X_3)	38	66.5	86.7	22.5	527.9
Economic Growth (X_4)	38	4.633	2.430	-6.160	8.880

From Table 2, it is obtained that the average BANSOS budget in East Java in 2022 is 197.1 billion rupiahs, with the lowest value of 18.6 billion rupiahs received by Mojokerto City and the highest value obtained by Jember Regency of 502.9 billion rupiahs. The average open unemployment rate in East Java in 2022 is 5.273 billion rupiahs, with the lowest value of 1.360 billion rupiahs received by Sumenep District and the highest value obtained by Sidoarjo District, amounting to 8.800 billion rupiahs. The average poverty percentage in East Java in 2022 is 72.969 billion rupiahs, with the lowest value of 63.390 billion rupiahs received by Sampang District and the highest value obtained by Surabaya City, amounting to 82.740 billion rupiahs. The average Gross Regional Domestic Product (GRDP) in East Java in 2022 is 66.5 billion rupiahs, with the lowest value of 22.5 billion rupiahs received by Pamekasan Regency and the highest value obtained by Kediri City of 527.9 billion rupiahs. The average economic growth in East Java in 2022 is 4.633 billion rupiahs with the lowest value of -6.160 billion rupiahs, received by Bojonegoro Regency and the highest value obtained by Tuban Regency amounting to 8.880 billion rupiahs.

First, the results of the OLS model parameter estimation (global model), parameter testing, and the measure of model goodness are given. The results of parameter testing are summarized in the following table.:

Table 3. The results of testing the significance of the OLS model parameters (global)

Variable	Parameter	Standard Error	Statistic *t*
Intercept	147.607	119.865	1.231
Open Unemployment Rate (X_1)	-2.145	11.707	-0.183
Poverty Percentage (X_2)	8.090	5.457	1.482
GRDP (X_3)	-0.169	0.211	-0.802
Economic Growth (X_4)	-2.480	7.850	-0.316

*Significant for a significant level (α) of 5%.

The value |t| > 2.1314 is obtained by testing the OLS model. α is 0.5. Thus, the OLS model above is not significant. The OLS model involving all variables is formulated in the following equation:

$$Y = 147{,}607 - 2{,}145\, X_1 + 8{,}090\, X_2 - 0{,}169\, X_3 - 2{,}480\, X_4 + e$$

In this OLS model, the AIC value is 468.024, and R-Square = 0.181. From the OLS modeling, the GWR results are shown in Table 4 below:

Table 4. OLS and GWR model results

Model	Kernel Type	Bandwidth (*h*)	AIC	R-Square
GWR	Fixed Gaussian (distance)	0.278	442.052	0.856
GWR	Fixed bi-square (distance)	1.102	463.491	0.585
GWR	Adaptive bi-square (NN)	-2147483648	-	-
GWR	Adaptive Gaussian (NN)	-2147483648	-	-

These results show that the GWR model with the Fixed Gaussian kernel (distance) is better than the OLS model with an AIC value of 442.052 and an R-Squared value of 0.856012. Each MGWR model estimation is given a test of geographic variability of local regression. A predictor variable is a global variable (no spatial variability) if the difference of the criterion (DoC) value is positive. In contrast, if the DoC value is negative, then the predictor will be said to be a local variable. From the output results of this test, an indication is obtained that all variable determination values are local variables, as follows:

Table 5. Summary results of testing the spatial variability of the fixed gaussian kernel

Variable	DIFF of Criterion	Value	Conclusion
Intercept	-101.327	Negative	Local Variable
Open unemployment rate (X_1)	-133.908	Negative	Local Variable

Variable	DIFF of Criterion	Value	Conclusion
poverty percentage (X_2)	-69.108	Negative	Local Variable
GRDP (X_3)	-14.357	Negative	Local Variable
economic growth (X_4)	0.501	Positive	Global Variable

Table 6. Summary results of fixed bi-square kernel spatial variability testing

Variable	DIFF of Criterion	Value	Conclusion
Intercept	-56.041	Negative	Local Variable
Open unemployment rate (X_1)	-27.660	Negative	Local Variable
Poverty percentage (X_2)	-16.228	Negative	Local Variable
GRDP (X_3)	-2.827	Negative	Local Variable
Economic growth (X_4)	0.831	Positive	Global Variable

Table 5 and Table 6 show that all research variables are considered local and global variables in this regression model because all DoC measures are negative and positive. Therefore, mixed geographically weighted regression (MGWR) modeling was conducted.

Table 7. Bandwidth AIC and R-Square results

Model	Kernel Type	Bandwidth (*h*)	AIC	R-Square
MGWR	Fixed Gaussian (distance)*	0.278	442.052	0.856
MGWR	Fixed bi-square (distance)	1.102	463.491	0.585
MGWR	Adaptive bi-square (NN)	-2147483648	-	-
MGWR	Adaptive Gaussian (NN)	-2147483648	-	-

From Table 7, it can be observed that the best model is indicated by the minimum AIC value and an R-Squared value close to 1, which corresponds to the MGWR model with a Fixed Gaussian (distance). Thus, the best MGWR model is the Fixed Gaussian (distance) model. The results of the subsequent MGWR modeling are summarized in Table 8 below:

Table 8. Best Model Comparison Results

Model	AIC	R-Square
OLS	468.024	0.181
GWR	442.052	0.856
MGWR	441.550	0.844*

***The best model**

From Table 8 above, when comparing the Global Linear Regression (OLS), GWR, and MGWR models using the Akaike Information Criteria (AIC), the MGWR model is the best model with fixed Gaussian kernel weights because it has the lowest AIC value, with AIC results for the Linear Regression model of 468.024, GWR AIC of 442.052 and MGWR AIC of 441.550. The R squared value for the linear regression model is 0.181, the GWR R squared is 0.856, and the MGWR R squared is 0.844; from the R-Squared value, the closest to 1 is the GWR model. However, from the smallest AIC value, MGWR is the best model for modeling the Social Assistance Budget in East Java in 2022.

From the results of MGWR modeling, test results were obtained for each district in East Java regarding the effect of partial/individual variables of open unemployment rate (X_1), poverty percentage (X_2), gross regional domestic product (X_3), and economic growth (X_4). The conclusions are shown in Table 9 below.

Table 9. Summary of MGWR modeling results

Districts/City	MGWR Model
Kediri District	y = -7.848 + 0.297 X_1 -2.815 X_2* + 0.147 X_3 + 0.272 X_4
Malang District	y = -7.965 + 0.522 X_1 - 2.504 X_2* + 0.084 X_3 - 0.560 X_4
Jember District	y = -8.172 - 1.373 X_1 - 2.199 X_2* + 1.979 X_3 + 1.070 X_4
Banyuwangi District	y = -8.222 + 1.845 X_1 - 3.058 X_2* + 2.168 X_3* + 2.257 X_4*

Districts/City	MGWR Model
Bondowoso District	y = -7.914 + 1.255 X_1 - 2.839 X_2 * + 1.277 X_3 + 1.609 X_4
Situbondo District	y = -7.700 + 0.915 X_1 - 2.502 X_2 * + 1.974 X_3 + 0.432 X_4
Probolinggo District	y = -7.777 + 0.263 X_1 - 2.476 X_2* + 1.626 X_3 + 0.357 X_4
Pasuruan District	y = -7.647 + 0.918 X_1 - 2.763 X_2* + 1.932 X_3 + 0.979 X_4
Sidoarjo District	y = -7.450 + 0.667 X_1 - 2.413 X_2* + 1.852 X_3 + 1.148 X_4
Mojokerto District	y = -7.469 + 0.795 X_1 - 2.384 X_2* + 0.983 X_3 + 1.324 X_4
Jombang District	y = -7.537 + 0.723 X_1 - 2.894 X_2* + 0.239 X_3 + 0.673 X_4
Nganjuk District	y = -7.605 + 0.201 X_1 - 2.761 X_2* - 0.039 X_3 + 0.472 X_4
Kediri City	y = -7.825 + 0.278 X_1 - 2.897 X_2* + 0.133 X_3 + 0.356 X_4
Malang City	y = -7.991 + 0.549 X_1 - 2.410 X_2* - 0.040 X_3 - 0.693 X_4
Probolinggo City	y = -7.740 + 0.292 X_1 - 2.544 X_2* + 1.720 X_3 + 0.660 X_4
Pasuruan City	y = -7.643 + 0.908 X_1 - 2.748 X_2* + 1.942 X_3 + 0.988 X_4
Mojokerto City	y = -7.460 + 0.804 X_1 - 2.337 X_2* + 0.952 X_3 + 1.280 X_4
Batu City	y = -7.883 + 0.195 X_1 * - 3.039 X_2* + 0.279 X_3 + 0.127X_4

*Significant for a significant level (α) of 5%.

Table 9 shows that the variant value of each observation variable has a significant value, meaning that the data from each variable is quite varied. Kediri District has a value of -2.815, which means that there is an influence on the percentage of poverty (X_2). Malang Regency has a value of -2.504, which means that there is an influence on the percentage of poverty (X_2). Kabupaten Jember has a value of -2.199, which means there is an influence on the percentage of poverty (X_2). Banyuwangi Regency has a value of -3.058, 2.168, and 2.257, which means that there is an influence on the percentage of poverty (X_2), GRDP (X_3), and economic growth (X_4). Bondowoso Regency has a value of -2.840, which means there is an influence on the percentage of poverty (X_2). Situbondo Regency has a value of -2.502, which means that there is an influence on the percentage of poverty (X_2). Probolinggo Regency has a value of -2.476, which means that there is an influence on the percentage of poverty (X_2). Pasuruan Regency has a value of -2.763, which means there is an influence on the percentage of poverty (X_2). Sidoarjo Regency has a value of -2.413, which means there is an influence on the percentage of poverty (X_2). Mojokerto Regency has a value of -2.384, which means there is an influence on the percentage of poverty (X_2). Jombang Regency has a value of -2.894, which means there is an influence on the percentage of poverty (X_2). Nganjuk Regency has a value of -2.761, which means there is an influence on the percentage of poverty (X_2). Kediri City has a value of 2.735, which means there is an influence on the percentage of poverty (X_2). Kediri City has a value of -2.897, which means there is an influence on the percentage of poverty (X_2). Malang City has a value of -2.410, which means that there is an influence on the percentage of poverty (X_2). Problinggo City has a value of -2.544, which means that there is an influence on the percentage of poverty (X_2). Pasuruan City has a value of -2.748, which means that there is an influence on the percentage of poverty (X_2). Mojokerto city has a value of -2.337, which means that there is an influence on the percentage of poverty (X_2). Batu City has a value of -3.039, which means there is an influence on the percentage of poverty (X_2).

4. DISCUSSIONS

The research results highlight significant regional disparities in East Java's social welfare budget, open unemployment rate, poverty percentage, Gross Regional Domestic Product (GRDP), and economic growth for 2022. The average BANSOS budget is 197.1 billion rupiahs, ranging from 18.6 billion in

Mojokerto City to 502.9 billion in Jember Regency, indicating varied social support needs. Open unemployment rates vary from 1.36 billion in Sumenep District to 8.8 billion in Sidoarjo District, suggesting differences in labor market dynamics. The poverty percentage average is 72.97 billion rupiahs, with Sampang District at the lower end and Surabaya City at the higher end, reflecting urban-rural disparities. GRDP ranges from 22.5 billion in Pamekasan Regency to 527.9 billion in Kediri City, highlighting economic imbalances. Economic growth ranges from -6.16 billion in Bojonegoro Regency to 8.88 billion in Tuban Regency, illustrating varied economic performance. These variations underscore the need for tailored policy approaches to address regional inequalities and promote balanced development across East Java.

The results indicate that the Ordinary Least Squares (OLS) model is insignificant, with an AIC of 468.024 and an R-Square of 0.180825, suggesting limited explanatory power. In contrast, the Geographically Weighted Regression (GWR) model with a Fixed Gaussian kernel performs better, evidenced by an AIC of 442.052 and an R-Square of 0.856012, indicating it captures spatial variability more effectively. However, the Mixed Geographically Weighted Regression (MGWR) model, with an AIC of 441.550 and an R-Square of 0.844216, proves to be the best overall, combining both local and global variables effectively, as it has the lowest AIC value and performs well in modeling the Social Assistance Budget (BANSOS) data for East Java in 2022.

Table 9 reveals substantial variability in the influence of the percentage of poverty (X2) across different districts and cities in East Java, with values ranging from -2.19858 to -3.05808, indicating that poverty significantly impacts these regions. Notably, the Banyuwangi Regency also influences Gross Regional Domestic Product (GRDP) and economic growth, reflecting a more complex economic interaction. Most other areas, including Bondowoso, Situbondo, and Mojokerto, consistently show significant adverse impacts of poverty, underscoring the need for region-specific policy interventions. This variability highlights the importance of tailored approaches to address the diverse economic and social challenges associated with poverty in East Java.

5. CONCLUSION

The study analyzes the 2022 Social Assistance Budget (BANSOS) in East Java, revealing significant regional disparities. The average BANSOS allocation is 197.1 billion rupiahs, with Mojokerto City receiving the lowest (18.6 billion) and Jember Regency the highest (502.9 billion). The open unemployment rate averages 5.273 billion rupiahs, with Sumenep District at the lowest (1.360 billion) and Sidoarjo District at the highest (8.800 billion). The average poverty percentage is 72.969 billion rupiahs, with Sampang District at 63.390 billion and Surabaya City at 82.740 billion. Gross Regional Domestic Product (GRDP) averages 66.5 billion rupiahs, with Pamekasan Regency at the lowest (22.5 billion) and Kediri City at the highest (527.9 billion). Economic growth averages 4.633 billion rupiahs, ranging from negative growth in Bojonegoro Regency (-6.160 billion) to high growth in Tuban Regency (8.880 billion). These variations reflect differences in economic conditions and the need for targeted development strategies.

The analysis shows that the Mixed Geographically Weighted Regression (MGWR) model with a fixed Gaussian kernel is the most effective for modeling BANSOS data, outperforming the Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) models based on its lower Akaike Information Criterion (AIC). The MGWR model accounts for both local and global spatial variability, offering a more accurate representation of the data. The results demonstrate that all predictor variables exhibit both local and global characteristics, emphasizing the model's ability to capture diverse spatial patterns. The MGWR model generates 18 distinct models, each reflecting regional differences in BANSOS budget allocation. The study highlights the model's effectiveness in addressing the spatial dynamics of BANSOS data and the need for region-specific policy interventions.

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