ISSN: 0852-0682, EISSN: 2460-3945
Forum Geografi, Vol 35 (1) July 2021: 1-13
DOI: 10.23917/forgeo.v35i1.12273
© Author(s) 2021. CC BY-NC-ND Attribution 4.0 License.

FORUM GEOGRAFI
Indonesian Journal of Spatial and Regional Analysis

Geographically Weighted Regression of Risk Factor of Stunting in Malang Regency, Indonesia

Adipandang Yudono [1,*], Joko Purnomo [2], Ratnaningsih Damayanti [2]
[1] Department of Urban and Regional Planning, Faculty of Engineering, Brawijaya University, Jl. MT. Haryono no.167, Malang, Indonesia
[2] Government Science Study Programme, Faculty of Social and Political Science, Brawijaya University, Jl. Veteran no.1, Malang, Indonesia
[*)] Corresponding Author (e-mail: adipandang@ub.ac.id)

Received: 09 October 2020 / Accepted: 21 December 2020 / Published: 01 August 2021

Abstract. Stunting has become a global concern. The incidence of stunting in the world contributes to 15% of under-five mortality, with 55 million children losing their health, and it is estimated to reduce the country's GDP level by up to 7%. In Indonesia, the incidence of stunting has become one of the main health problems that need to be solved immediately. Malang Regency is one of the districts in East Java Province that has received the spotlight regarding this problem. This research examined the risk factors of stunting in Malang Regency through Geographically Weighted Regression (GWR). GWR was carried out to calculate the correlation between predetermined demographic, health, and economic variables, which were assumed to influence risk factors of stunting. GWR allocation and model examinations are important in understanding risk factors of stunting in the study of disease transmission in the investigation zone. Based on GWR analysis, the research shows that only four (4) sub-variables were significant: the number of poor people, level of education, number of health facilities, and access to health facilities. We also found that Lawang, Gondanglegi, and Turen districts have high-risk areas to stunting. Therefore, within this study that correlates to government policy to decrease or eliminate stunting incidents, districts belonging to the high-risk class should be prioritized or concerned. Moreover, based on LISA, some districts are affected by the risk factors of stunting from the surrounding districts with higher stunting potential value such as Gondanglegi and Pagelaran Districts.

Keywords: Stunting, Spatial, Geographic Information System, Geographically Weighted Regression.

1. Introduction

Stunting has become a global concern. The incidence of stunting in the world contributes to 15% of under-five mortality, with 55 million children losing their health (Bhutta, 2013), and it was estimated to reduce a country's GDP level by 7% (Galasso and Wagstaff, 2018). Stunting is a chronic nutritional problem in children under five, characterized by shorter height than other children their age. Children who suffer from stunting will be more susceptible to disease, and as adults, they are at risk of degenerative diseases (Indonesian Ministry of Health, 2017). Although the incidence of stunting has decreased in Indonesia, the incidence of stunting is still relatively high at 30% (Riskesdas, 2018); the prevalence of stunting is above the threshold set by WHO of 20% (WHO, 2014).

In the global context, various endeavours have been actualized to overcome stunting. Thus, the United Nations Sustainable Development Goals (SDGs) intend to end a wide range of stunting before the end of 2030. This arrangement could decrease to

4% yearly and afterward proposed to reduce under-five kids stunted, from 171 million in 2010 to 100 million toward the finish of 2025. Nevertheless, at this diminished rate, the size of stunting is anticipated not to reach over 20% (127 million) by 2025 (Fanzo, 2018).

Sustainable Development Goals (SDGs) is a global sustainable development program that aims to prosper the global community and conserve nature with 17 main objectives and 169 targets to be achieved by 2030. SDGs have several goals, including eliminating hunger, achieving good food and nutrition security, and improving sustainable agriculture. The target set is to reduce the stunting rate by 20% by 2025. This goal is in line with the situation in Indonesia, which still has a high prevalence of stunting caused by a prolonged lack of nutritional intake (Yosza, 2018).

Malang Regency is one of the districts in East Java Province that has received the spotlight regarding the problem of stunting. It is estimated by the local government of Malang Regency that there were 30,323 out of a total of 154,188 toddlers in Malang Regency who are stunted (Plenary Meeting of the Malang Regency DPRD, 2018). The stunting rate in 2018 generated confusion because based on data from the Regional People's Representative Assembly (DPRD), since 2017, Malang Regency has had no stunting problems considering the implementation of the Contraceptive for Women at Risk (CONTRA WAR) program and the Community-Based Integrated Epidemiological Surveillance program (SUTERA EMAS). Stunting is associated with poverty as its influencing factor. Surprisingly, poverty in Malang Regency was reduced from 11.49% (2016) to 11.04 (2017), but the decreasing stunting cases do not follow this.

Since stunting is challenging to solve only by examining personal health factors, some studies try to find alternative solutions from a different perspective by involving spatial elements in research. Several previous research results showed that Geographical Information Systems (GIS) is a valuable tool for understanding public health problems in a spatial context (Marx et al., 2014). The existing studies have demonstrated the significance of GIS in planning, examining public health issues, specifically stunting cases (Hailu et al., 2020; Almasi et al., 2019; Fitriangga et al., 2020; Fadmi et al., 2018; Pramoedyo et al., 2020). Those studies agreed that spatial elements have a significant influence in determining stunting cases.

Spatial relationships should be considered in the study of stunting based on spatial analysis. This refers to a fundamental evaluation of geography analysis of the law expressed by Tobler "Everything is related with everything else, but close things are more related than farther things." (Fotheringham et al., 2003). Geographically-Weighted Regression (GWR) is one of the spatial techniques that is used to analyse the spatial relationship. Weight in GWR can illustrate the proximity of affiliations amongst domains/areas. The correctness of weighting is essential due to the weighting value performing the geographical orientation of data (Yrigoyen et al., 2006).

This research aims to conduct a spatial analysis of risk factors of stunting in Malang Regency using the Geographic Information System (GIS). The urgency of this research was carried out to ensure data validation on the incidence of stunting in Malang Regency, which will have implications for the handling and reduction of risk factors of stunting in Malang Regency. Apart from the GIS method, this study employed the Geographically-Weighed Regression (GWR) technique. The results of this study can also be used for early detection of the distribution of stunting areas in Malang Regency. Having instruments for early detection of stunting will make it easier to precisely control and reduce stunting rates based on the specific variables that have the most influence on the target area.

2. Research Method

2.1. Study area

This research was conducted in Malang Regency, East Java Province. Malang Regency is located in the southern part of East Java

Province which is the easternmost part of Java Island. This research data was taken from 33 sub-districts, namely Donomulyo, Kalipare, Pagak, Bantur, Gedangan, Sumbermanjing Wetan, Dampit, Tirtoyudo, Ampelgading, Poncokusumo, Wajak, Turen, Bululawang, Gondanglegi, Performances, Kepanjen, Sumberpucung, Kromengan, Ngajum, Wonosari , Wagir, Pakisaji, Tajinan, Tumpang, Pakis, Jabung, Lawang, Singosari, Karangploso, Dau, Pujon, Ngantang, and Kasembon (See Figure 1).

The area of Malang Regency is 3,530.65 km2. Malang Regency is the second largest district in East Java Province after Banyuwangi Regency and is the second most populous district in East Java Province after Surabaya City. The population of Malang Regency in 2019 was 2,606.20 thousand people. Singosari sub-district is the sub-district with the largest population, but Pakis sub-district is the sub-district with the highest population density. The number of poor people in 2019 was 246,600 people or 9.47%(Statistics Indonesia, 2020).

The number of stunting toddlers in Malang Regency in 2019 was 18,388 toddlers consisting of short toddlers and very short toddlers. The number of stunting toddlers is divided into 33 sub-districts where the highest is Turen sub-district, followed by Pujon, then Gondanglegi (Government of Malang Regency, 2019a; Malang Health Department, 2019). Malang Regency has 39 public health centers, there are 22 hospitals, 83 medical clinics, 2,842 integrated service posts, and 337 village maternity cottages(Statistics Indonesia, 2020).

In Malang Regency there are 1,384 Kindergartens, 1,489 Elementary Schools, 535 Junior High Schools, and 289 Senior High Schools. In 2019, the Elementary School Participation Rate was 99.48%, the Junior High School Participation Rate was 87.39%, and the Senior High School Participation Rate was 53.39 percent. Thus, there are still many young people in Malang Regency who only graduate from Junior High School(Statistics Indonesia, 2020).

Data from the Office of the Ministry of Religion shows that in 2019 the population of Malang Regency was mostly married at the age of 21-30 years. However, there are still many people who get married at a young age or under 19 years old. A total of 255 men and 354 women were married under the age of 19(Government of Malang Regency, 2019b).

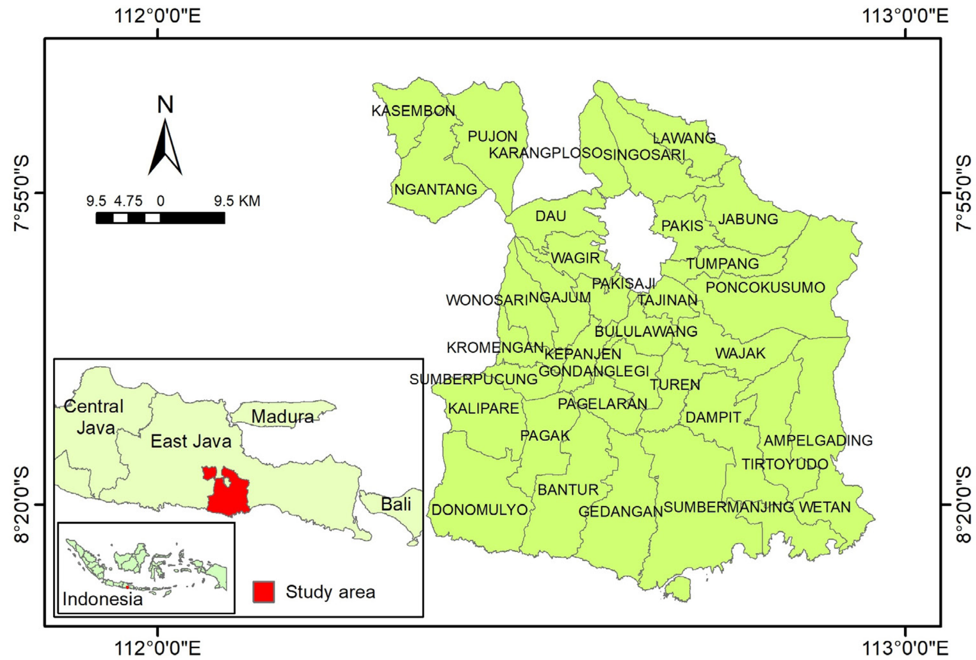

Figure 1. Malang Regency Map

2.2. Data and pre-processing

Data for the GWR analysis is prepared using the compilation of secondary data from the Central Bureau of Statistics, Health Service Office, Planning and Development Agencies, and Social Service of Malang Regency. For analysis, the statistical data obtained from the governments were then to be transformed into spatial data with shapefile (shp) format, geometric form in the form of administrative polygons that collected from the Indonesian Geospatial Information Agency (BIG), all of which were for later processing in the GIS Software through Open Geoda and ArcGIS 10.7.1.

2.3. Research framework

This research was conducted based on the quantitative method using GWR analysis techniques combined with regression analysis (Figure 2). GWR technique was used to examine the spatial relationship, while regression analysis was employed to explore the risk factor of stunting. Spatial regression analysis (GWR) is one of the statistical methods used to determine the relationship between the dependent and independent variables by considering space or location. The independent variable in this study is the number of stunting incidences. The dependent variables that will be used in this study are demography, health, and economy. Measurements were based on conditions, Rate of Participation, and Density.

The research framework consists of five steps (Figure 2): (1) literature review to define variables and sub-variables, (2) validate the selected variables by factor analysis, (3) the analysis of risk factors of stunting using a regression model, (4) Lagrange Multiplier (LM) test for to select the spatial regression model, and (5) Local Indicator Spatial Autocorrelation (LISA) analysis to identify the relationship between an observation location to another observation location (Lee and Wong, 2001).

The regression model is a statistical method for estimating model parameters formed by linking responses and predictors (Drapper & Smith, 1992). Classical regression modeling is used to determine the relationship between predictor variables and the incidence of stunting. The existence of spatial effects is common from one region to another. The observed response variables are related to the results of observations in different areas, especially those close to each other. A spatial relationship in the response variable will cause the estimation to be incorrect because the assumption of random errors is violated. Spatial dependencies analysis is needed to determine the types of spatial regression (GWR) to solve the problem.

The determination of the use of the LM-lag and LM-error models can be seen from the probability value of the LM test results. If the probability value is significant in the LM-lag, then it is continued in the form of spatial lag model or spatial autoregressive model (SAR), and if the significant value is on the LM-error, it is continued in the spatial error model (SEM). However, if the probability value of LM-Lag and LM-Error shows a significant value, it is followed by looking at the Robust value. If the robust value on the LM-Lag is significant, then the SAR model will be selected, and if the robust value at the LM-Error is significant, then the SEM model will be selected. If the robust value in both models of LM-Lag and LM-Error values is significant but does not have a significant robust value, then the researchers proceed to SAR because LM-Lag identifies the model according to the dependency of the lag or error. If the values are not significant for the two probability values, then the model chosen is classical modeling without any spatial influence in the regression model.

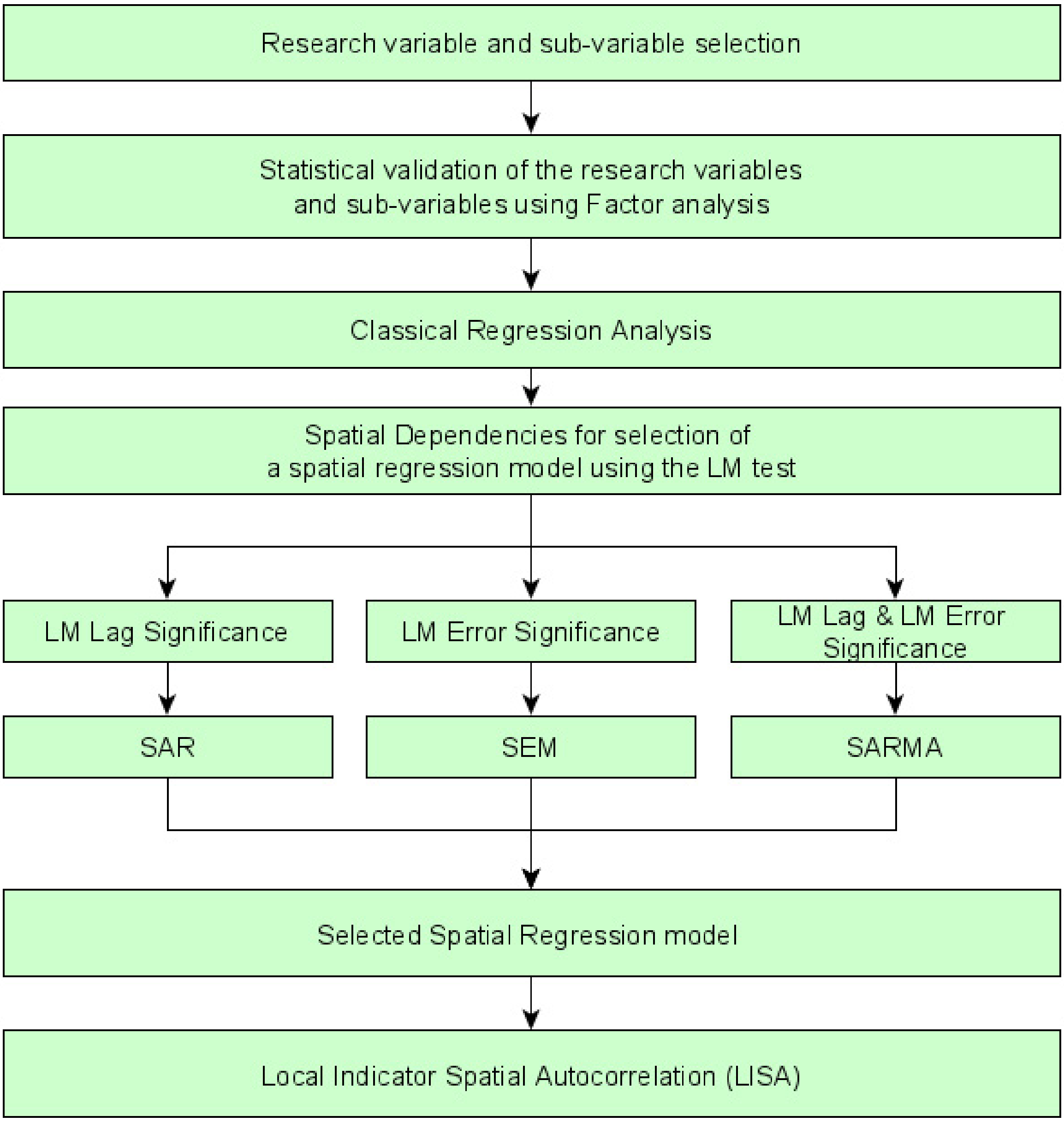

Figure 2. Research framework

3. Results

3.1. The selection of research variable and sub-variables

Different from previous GWR stunting research in which the research variables had been justified by themselves, this research looked for the appropriate variables and sub-variables by the reviewed publication of stunting articles on Google Search Engine based on papers published in the last five years—from 2015 to 2020—until 151 papers were finally found on stunting and the environment. The papers were analyzed, focusing on keywords and paper abstracts in determining research variables until 32 related articles were found. At the end of research variables and sub-variables selection, the researchers determined 4 variables with 12 sub-variables, which can be seen in Table 1.

Table 1. Research variables and sub-variables

Variable	Sub-variable
Stunting	Number of stunting cases per district
Demographics	Population density per district
	Education level per district
	Early marriage rates per district
Health	Number of health facilities per district
	Number of health workers per district
	Access to health facilities per district
	Availability of clean water and sanitation per district
	Number of baby health services per district
Economics	Income per district
	Percentage of poor people per district
	Rice for prosperity program

3.2. Factor Analysis

Factor analysis was conducted using Statistical Package for the Social Science (SPSS) to determine which variables or sub-variables are suitable for inclusion in regression analysis. In factor analysis, the variables or sub-variables being analysed must have sufficiently correlated data matrices, so that factor analysis can be carried out to assess the correlation. In this test, all variables or sub-variables were analysed to determine which variables or sub-variables can be processed further and which variables or sub-variables need to be eliminated. Each variable or sub-variables must have an MSA value > 0.5 to be processed further in this test. If there is a variable or sub-variables with MSA value less than 0.5, then the variable or sub-variables should be eliminated for the subsequent analysis. The following are the results of the MSA test on stunting sub-variables in Malang Regency. Based on Table 2, it can be seen that there is a sub-variable having an MSA value < 0.5, namely the rice for prosperity program per recipient district. Therefore, this sub-variable needs to be excluded, and the rest of sub-variables can be analysed further.

Table 2. Value of MSA I – Research Variables

No.	Variable	MSA Value	Description
1.	Population density per district	0.658	Valid
2.	Education level per district	0.804	Valid
3.	Early marriage rates per district	0.785	Valid
4.	Number of health facilities per district	0.946	Valid
5.	Number of health workers per district	0.830	Valid
6.	Access to health facilities per district	0.505	Valid
7.	Availability of clean water	0.865	Valid
8.	Availability of sanitation per district	0.938	Valid
9.	Number of baby health services per district	0.900	Valid
10.	Proportion of poor people per district	0.804	Valid
11.	Rice for prosperity program	0.145	Invalid

3.3. Classical Regression Model

The classical regression model is used to determine the relationship between predictor variables and the incidence of stunting. In the classical regression model test, the component that is considered to decide which dependent variable can be used in the next statistical analysis stage is the Probability value (P-Value). From the general formulation, if the test for the dependent variable in the statistical method has a *P*-value < 0.05, this indicates that the variable has an influence on the independent variable. Then, the coefficient of the selected variables will be used in equation. The coefficient is the multiplier in an equation expression. In this classical regression model, the stunting incident variable was selected as the independent variable (Y), while the three variables (demography, health, economy) had a role as the dependent variable with ten sub-variables, namely: X1 = population density; X2 = education level; X3 = early marriage; X4 = number of health facilities; X5 = number of health workers; X6 = access to health facilities; X7 = clean water coverage; X8 = sanitary coverage; X9 = baby health services coverage; X10 = poor people.

Table 3 presents the results of the classical regression model testing for the correlation independent and dependent variables of risk factor of stunting in Malang Regency. Based on the classical regression test, the result shows that of the 10 sub-variables that affect the incidence of stunting, there are 4 significant sub-variables with a probability value of < 0.05, namely the sub-variables of education level, number of health facilities, access to health facilities, and the poor people. Based on Table 3, the classical regression equation is expressed in the Equation 1.

$$yi = -150.492 - 9.77869\ X2\ \text{(education level)} + 14.2587\ X4\ \text{(number of health facilities)} - 14.\ 3507\ X6\ \text{(access to health facilities)} + 20.4708\ X10\text{(poor people)} \quad (1)$$

The classical regression model (See Equation 1) can be interpreted that—if other factors are considered constant—when the level of education (X2) increases by 1 unit, the predicted value of stunting incidence will decrease 9.77869. Then, when the number of health facilities (X4) increases by 1 unit, the predicted value of the incidence of stunting will decrease. The increasing number of health facilities has a value of 14.2587 which can be interpreted that the presence of health facilities can record the incidence of stunting. In addition, when access to health facilities (X6) increases by 1 unit, the predicted value of the incidence of stunting will decrease by 14.3507, and when the number of poor people (X10) increases by 1 unit, it will be predicted to increase the incidence of stunting by 20.4708.

Table 3. Classical Regression Results for the Risk factor of Stunting

Sub Variable	Coefficient	P-Value
Constant	-150.492	0.49616
Population density	0.0170134	0.102592
Education level	-9.77869	0.00449
Early marriage	1.9632	0.58901
Number of health facilities	14.2587	0.00149
Number of health workers	5.31175	0.23713
Access to health facilities	-14.3057	0.03171
Clean water coverage	-0.0307446	0.06369
Sanitary coverage	0.00346745	0.76523
Baby health services coverage	0.317228	0.62774
Poor people	20.4708	0.00477
R2 = 0.671565		

3.4. Spatial Dependencies

The test was conducted to determine the existence of spatial dependencies for the possibility of running the GWR model, namely the Moran's I test statistic and LM test. Similar to the classical regression model, the component considered to decide the type of spatial dependencies used in the GWR stage is the Probability value (P-Value). If the test for the model has a *P*-value <0.05, this indicates that the type of spatial dependencies has a significant model to be selected in GWR. The test results are attached in Table 4.

Table 4. Spatial Dependency Test Results

Test	P-Value
Moran's I (error)	0.23757
Lagrange Multiplier (lag)	0.73124
Robust LM (lag)	0.14586
Robust LM (error)	0.03326
Lagrange Multiplier (SARMA)	0.09776

Based on Table 4, it is known that the *p*-value of Moran's is not significant at α = 0.05, which means that there is no spatial dependency. Also, in the Lagrange Multiplier test, none of the *p* - values are significant, which means that there is no spatial dependence on the lag value. However, only one significant error value is the Robust LM (error) value with a probability value of 0.03326. Thus, the GWR model of the risk factor of stunting can be implemented for Malang Regency is the Spatial Error Model.

3.5. Spatial Error Model (SEM)

After the spatial dependency test was carried out, producing a suitable model to predict the risk factor of stunting in the study area, the output results from SEM modelling of each sub-variable value are expressed in Table 5. Like the classical regression model, the component that is considered to decide the dependent variable used in the subsequent statistical analysis stage is the Probability value (P-Value). From the general formulation, if the test for the dependent variable in the statistical method has a *P*-value <0.05, this indicates that the variable influences the independent variable. Based on the GeoDa output results in Table 5, the SEM results show a spatial dependence on the error where the four sub-variables have a significant probability value (Equation 2).

Table 5. SEM output results

Sub-variable	Coefficient	P-Value
Constant	226.83	0.07853
Education level	-7.00009	0.00845
Number of health facilities	17.1394	0.00000
Access to health facilities	-13.1362	0.00040
Poor people	14.6186	0.00919
Lambda	-0.284981	0.24922
R2 = 0.486654		

yi = 226.83 – 7.00009 *X2* (education level) + 17.1394 *X4* (number of health facilities) – 13.1362 *X6* (access to health facilities) + 14.6186 *X10* (poor people) + ui (2)

where :

u_i =

yi = Number of Stunting Cases in District i

ui = The spatial residual of District i

wij = Spatial weights / weights matrix

εi = Residual from district I

This study employed the simplest method in the classification, using the natural breaks method by sorting stunting categories based on the SEM value equation into three groups (high, medium, and low) to visualize the results (Figure 3).

Based on Spatial Dependencies test, the selected Spatial Regression Model was Spatial Error Model (SEM). The SEM model (See Equation 2) can be interpreted that the effect of the level of education in Malang Regency is the same for each district in Malang Regency with an elasticity of -7.00009. If other factors are considered constant, when the value of the level of education in a district increases by 1 unit, the stunting value will decrease by 7.00009 units.

The effect of the number of health facilities on stunting has a positive coefficient of 17.1394 which means that if other factors are considered constant, when the number of health facilities in a district increases by 1 unit, the stunting value will increase by 17.1394 units. This is because the more the number of health facilities that exists, the more cases of stunting will be recorded.

The effect of access to health facilities on stunting is the same for each district in Malang Regency with an elasticity of -13.1362. It means that if other factors are considered constant, when the value of access to health facilities in a district increases by 1 unit, the stunting value will decrease by 13.1362 units. This is because, the farther the access to health facilities in a district, the lower the rate of recording of stunting cases will be. This is likely due to the lack of public interest in checking their children's condition due to the distance to health facilities.

Meanwhile, the effect of the number of poor people on stunting is the same for each district in Malang Regency with an elasticity of 14.6186. If other factors are considered constant, when the value of the number of poor people in a district increases by 1 unit, the stunting value will increase by 14.6186 units. Furthermore, the values of significant variables in each district in Malang Regency are entered into the Spatial Error Model regression equation.

From the spatial distribution of risk classes regarding the incidence of stunting in Malang Regency (See Figure 3), the following results were obtained: (1) he Low risk factor of stunting are located in Karangploso, Ampelgading, Gedangan, Wonosari, Kalipare, Wagir, Dampit, Singosari, Bululawang, Pakis, Bantur, Dau, Wajak, Poncokusumo, Kromengan, Donomulyo, Pagak, Ngajum, Jabung, and Tajinan district; (2) the Moderate risk factor of stunting are located in Pujon, Ngantang, Kasembon, Pakisaji, Kepanjen, Tumpang, Sumberpucung, Pagelaran, Tirtoyudo and Sumbermanjingwetan district; (3) the high-risk factor of stunting are located in Lawang, Gondanglegi and Turen district.

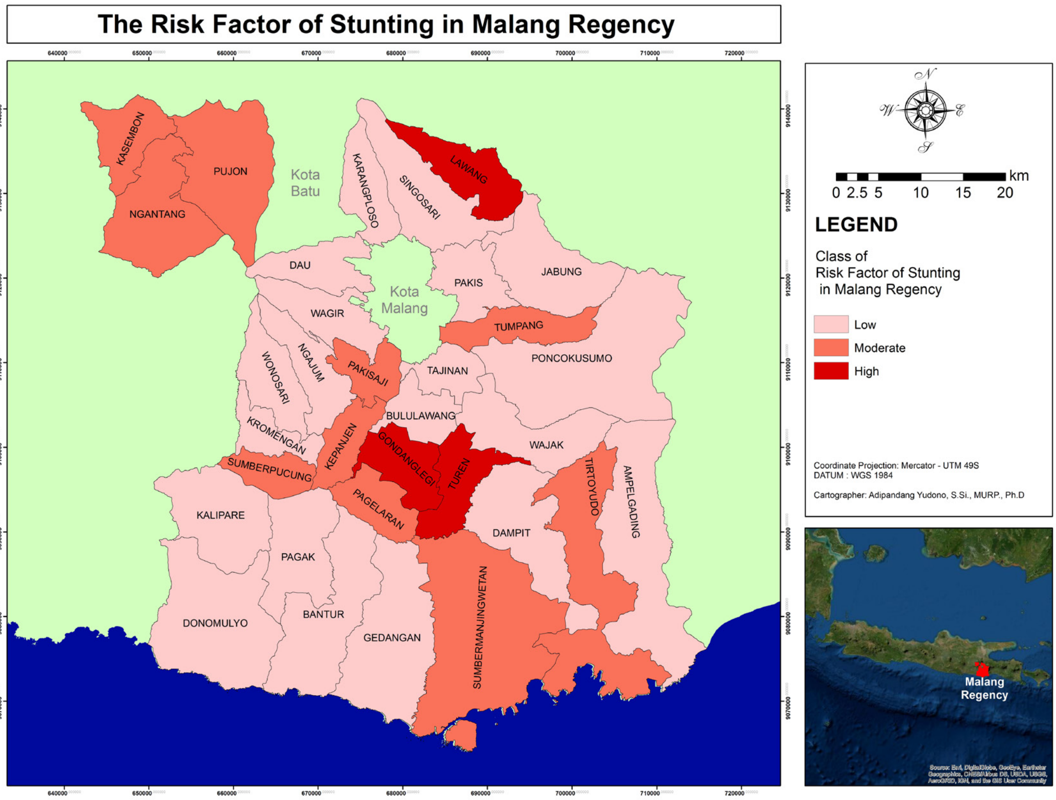

Figure 3. The Risk Factor Class of Stunting in Malang Regency with four selected variables from the classical regression tests (poor population, education level, number of health facilities, and access to health facilities)

3.6. Local Indicator Spatial Autocorrelation (LISA)

The output of the district-level stunting risk will be the input for assessing the spatial relationship related to the influence of the surrounding environment from a dominant characteristic area in a case, i.e. the risk factor of stunting (Figure 4). The LISA processing was carried out again in the OpenGeoDa software.

The next step of exploring risk factors of stunting in Malang regency was conducting spatial autocorrelation. Spatial autocorrelation predicts the correlation between the observed values related to the spatial location of the same variable. The existence of spatial autocorrelation indicates a relationship between the attribute values of a location and the attribute values at adjacent or neighboring locations. In this study, the presence or absence of spatial autocorrelation was determined using the Local Indicator Spatial Autocorrelation (LISA). LISA was used to determine the local spatial autocorrelation of the stunting risk value in each district of Malang Regency.

Figure 4 can be interpreted that based on the LISA study, 2 spatial autocorrelation patterns have been produced: High-High and Low-High. Furthermore, it can be interpreted that districts included in the High-High category (dark red colour) have high potential for stunting which can affect the surrounding districts. Based on the examination, two areas have been obtained, namely, Gondanglegi and Pagelaran district. Meanwhile, for the Low-High pattern (light blue color), these districts are at risk of being affected by stunting from the surrounding districts in which potential stunting value is relatively higher. So the risky ones that can increase the stunting rate here are Bululawang and Dampit districts.

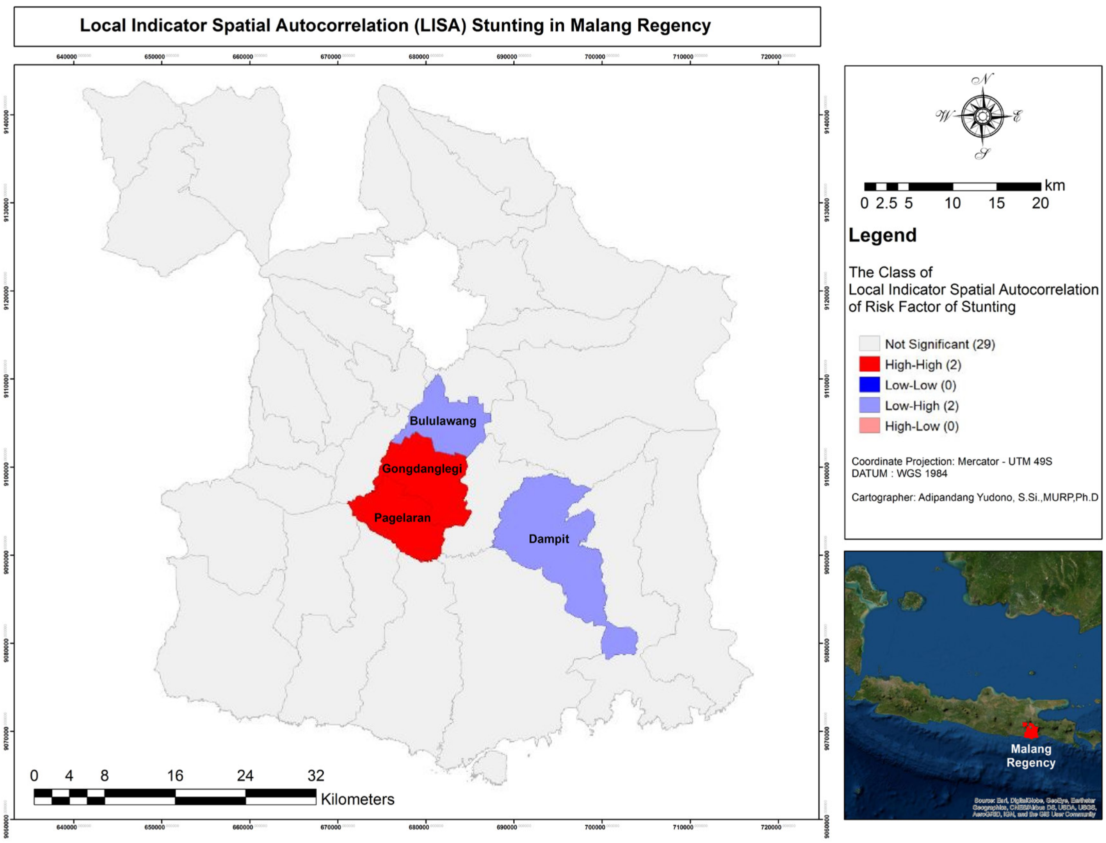

Figure 4. LISA Risk Factor of Stunting in Districts in Malang Regency

4. Discussion

This study demonstrates that GWR can predict the incidents of stunting with spatial approach. Some similar approach has been demonstrated by previous studies such as Muche et al. (2021), Alam et al. (2021), Almasi et al. (2019), and Menon et al. (2018). The application in stunting analysis in Indonesia also has been conducted by Alam et al. (2021). However, this study implements more complex variables, including the number of poor people, level of education, number of health facilities, and access to health facilities that have been validated by linear regression. This analysis is important to present the variation of stunting cases based on the characteristics of geographic location Muche et al. (2021). Furthermore, knowing the forecasts of primary components from a public health case and the predictions of the affected places would help decision-makers design effective and efficient policies.

The finding of this study's use of the GWR method to determine the risk of stunting factors in Malang Regency will be used to set priorities for dealing with specific factors, such as education level, number of health facilities, access to health facilities, and the poor, in Indonesian locations with a high risk of stunting. Districts of Lawang, Turen, and Gondanglegi.

Furthermore, to decrease stunting events in Malang Regency, handling regions that become epicentre that have an enormous impact on the spread of stunting risk and locations most sensitive to receiving stunting risks must be secured. For example, the LISA technique identified two places prone to stunting risk transmission: Gondanglegi and Pagelaran, which are epicentres projected to impact the spread of stunting occurrences to the surrounding area. Bululawang and Dampit, on the other hand, are particularly vulnerable to the effects of nearby high stunting areas.

5. Conclusion

GWR is able to understand risk factors of stunting in the study of disease transmission in the investigation zone. Based on GWR method in examining the risk factors of stunting, the research findings expressed that from the classical regression test, only four (4) significant sub-variables were obtained: the number of poor people, level of education, number of health facilities, and access to health facilities. Furthermore, according to GWR, the districs in Malang regency that have high-risk factors of stunting cases are Lawang, Gondanglegi, and Turen district. Therefore, within this study that correlates to government policy to decrease or eliminate stunting incidents, districts belonging to the high-risk class should be prioritized or concerned. Based on LISA study, two spatial autocorrelation patterns have been produced, namely High-High and Low-High. It can be interpreted that districts belonging in the High-High category have a high potential for stunting which can affect the surrounding districts, in this case, Gondanglegi and Pagelaran district. Meanwhile, for the Low-High pattern, these districts are at risk of being affected by risk factor of stunting from the surrounding districts with higher stunting potential value. As a result, the districts prone to increased stunting rate are Bululawang and Dampit districts. Finally, based on GWR analysis of risk factors of stunting in Malang regency, the local government should prioritize eliminating the case of stunting in Lawang, Gondanglegi, Pagelaran, and Turen district.

Acknowledgements

This paper was conducted as a legacy for our best friend Joko Purnomo (1978–2020) who passed away during this research. I would like to thank Brawijaya University's Research and Community Services Institution for its support for this research's funding. Without which, this research wouldn't have been accomplished.

References

Alam, F. K., Y. Widyaningsih, and S. Nurrohmah. (2021). "Geographically Weighted Logistic Regression Modeling on Stunting Cases in Indonesia." In Journal of Physics: Conference Series, IOP Publishing, 012085.

Almasi, A., Zangeneh, A., Saeidi, S., Rahimi Naderi, S., Choobtashani, M., Saeidi, F., ... & Ziapour, A. (2019). Study of the Spatial Pattern of Malnutrition (Stunting, Wasting and Overweight) in Countries in the World Using Geographic Information System. International Journal of Pediatrics, 7(10), 10269-10281.

Anselin, L., (1988), Spatial Econometrics: Methods and Models. Dordrecht: Kluwer Academic Publishers.

Bhutta, Z. A., J. K. Das, A. Rizvi, M. F. Gaffey, N. Walker, S. Horton, P. Webb, A. Lartey, R. E. Black, G., (2013), Lancet Nutrition Interventions Review, Maternal and G. Child Nutrition Study."Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost?" Lancet 382(9890): 452-477.

Drapper, N. R., dan Smith, H., (1992), Applied Regression Analysis 3rd Edition, Wiley & Sons, Canada

Fadmi, F. R., Mulyani, S., & Buton, L. D. (2018). Geographically Weighted Regression (GWR) Approach in the Modeling of Malnutrition and the Influencing Factors in Muna Regency. Indian Journal of Public Health Research & Development, 9(6), 351-356.

Fanzo,J,.*et al, (*2018). Global nutrition report: shining a light to spur action on nutrition.

Fitriangga, A., Albilardo, G., & Pramulya, M. (2020). DISTRIBUTION AND SPATIAL PATTERN ANALYSIS ON MALNUTRITION CASES: A CASE STUDY IN PONTIANAK CITY. Malaysian Journal of Public Health Medicine, 20(2), 56-64.

Fotheringham AS, Brunsdon C, and Charlton M. (2003). Geographically Weighted Regression: The Analysis of Spatially Varying Relationships. John Wiley & Sons.

Galasso E., Wagstaff A., (2018), The Aggregate Income Losses from Childhood Stunting and the Returns to a Nutrition Interventino Aimed at Reducing Stunting, Policy Research Working Paper 8536, Development Economics, Development Research Group, World Bank Group, 2018.

Government of Malang Regency, (2019a), Dinas Kesehatan Kabupaten Malang. 2019. "Rekap Hasil Operasi Timbang Kabupaten Malang 2019." Kabupaten Malang. (Recapitulation of Weigh Operation Results for Malang Regency 2019.)

Government of Malang Regency, (2019b), Kantor Kementrian Agama Kabupaten Malang. 2019. "Laporan Usia Pengantin." Kabupaten Malang. (Wedding Report)

Hailu, B. A., Bogale, G. G., & Beyene, J. (2020). Spatial heterogeneity and factors influencing stunting and severe stunting among under-5 children in Ethiopia: spatial and multilevel analysis. Scientific reports, 10(1), 1-10.

Kementerian Kesehatan RI (Indonesian Ministry of Health), (2017), Kesehatan Indonesia.

Lee J. and Wong S.W.D. (2001). Statistical Analysis with Arcview GIS, John Willey & Sons, Inc., United Stated of America

Marx S, Phalkey R, Aranda-Jan CB, Profe J, Sauerborn R, Höfle B. (2014). Geographic information analysis and web-based geoportals to explore malnutrition in Sub-Saharan Africa: a systematic review of approaches. BMC public health; 14(1):1189-96.

Menon, Purnima, Derek Headey, Rasmi Avula, and Phuong Hong Nguyen. (2018). "Understanding the Geographical Burden of Stunting in India: A Regression-Decomposition Analysis of District-Level Data from 2015–16." Maternal & child nutrition 14(4): e12620.

Muche, Amare, Mequannent Sharew Melaku, Erkihun Tadesse Amsalu, and Metadel Adane. (2021). "Using Geographically Weighted Regression Analysis to Cluster Under-Nutrition and Its Predictors among under-Five Children in Ethiopia: Evidence from Demographic and Health Survey." PloS one 16(5): e0248156.

Pramoedyo, H., Mudjiono, M., Fernandes, A. A., Ardianti, D., & Septiani, K. (2020). Determination of Stunting Risk Factors Using Spatial Interpolation GWR Kriging in Malang Regency. Mutiara Medika: Jurnal Kedokteran dan Kesehatan, 20(2), 98-104.

RISKESDAS, (2018), Laporan Nasional Riset Kesehatan Dasar 2018, Badan Penelitian dan Pengembangan Kesehatan, Kementerian Kesehatan RI (The National Report for Basic Health Research 2018, Health Research and Development Agency, Ministry of Health of the Republic of Indonesia.)

Statistics Indonesia, (2020), BPS Kabupaten Kabupaten Malang. 2020. *Kabupaten Malang Dalam Angka 2020*. Edited by Wahyudi Furqandari. *Badan Pusat Statistik Malang*. BPS Kabupaten Malang (Statistics of Malang Regency Year 2020).

World Health Organization, (2014), Global Nutrition Targets 2025: Stunting Policy Brief. Geneva: WHO.

Yosza, Frandy. (2018). Kejadian Stunting di Indonesia (Stunting case in Indonesia). Accessed from: himaep.feb.unair.ac.id/thinking-out- cloud/128-stunting-di- indonesia.html.

Yrigoyen CC, Rodríguez IG, and Otero JV. (2006). Modeling Spatial Variations in Household Disposable Income with Geographically Weighted Regression. Madrid: Instituto L.R. Klein. p. 40